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NATIONAL MUSEUM MELBOURNE

Vol. XXII. Part 11.

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The Journal of the Department of Agriculture of Victoria, Australia.

November, 1924.

PRINCIPAL CONTENTS

Wheat and Its Cultivation

Apricot Growing

Fertilizers and the Fertilizer Industry

Cotton-Growing Experiments

Cost of Rearing and Fattening Pigs

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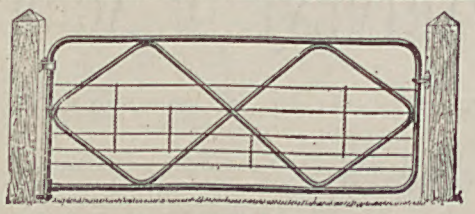

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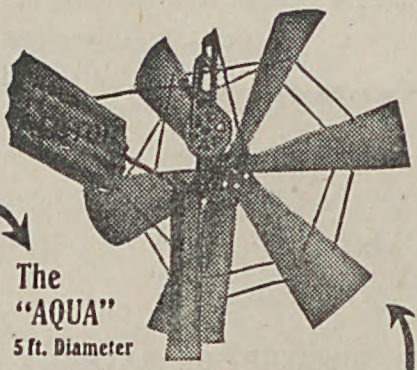

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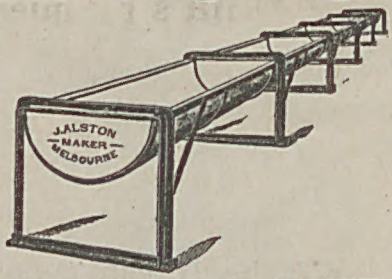

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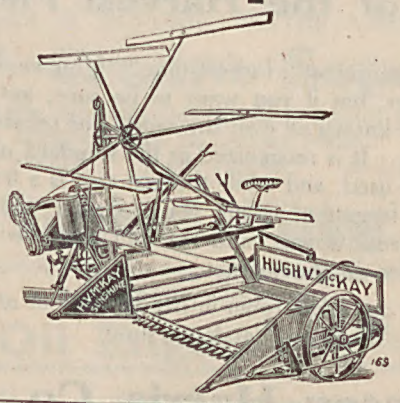

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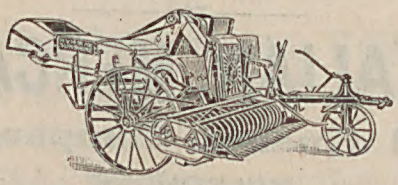

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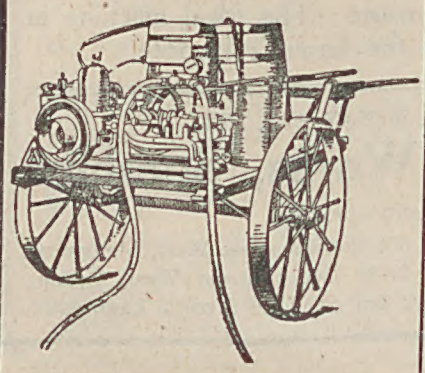

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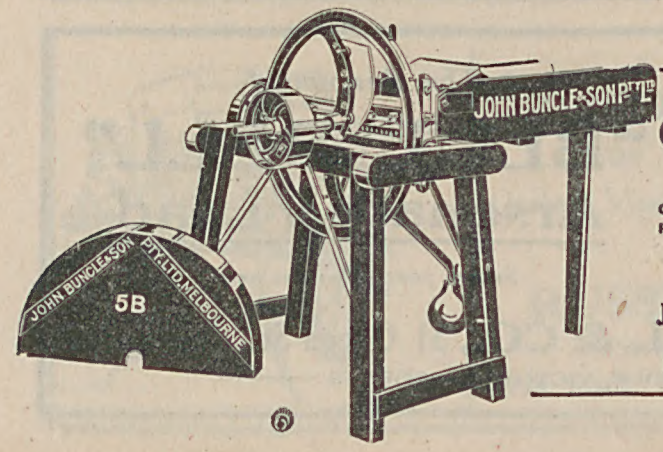

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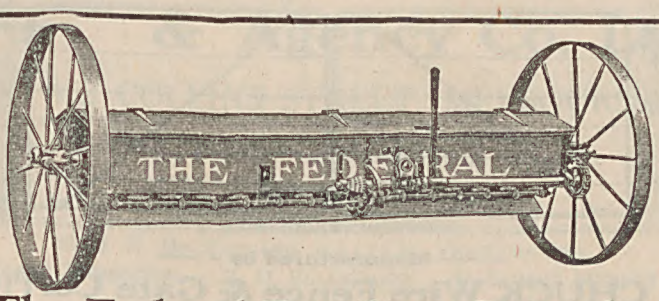

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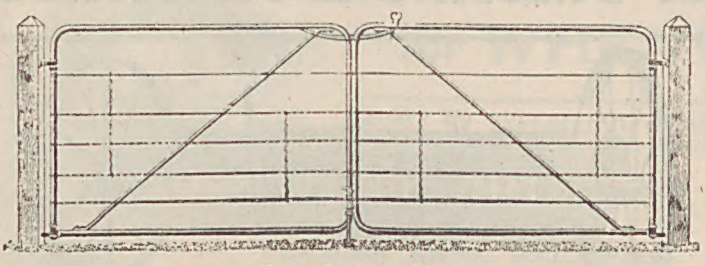

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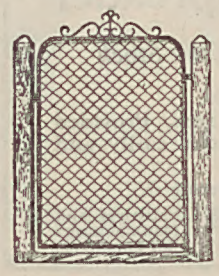

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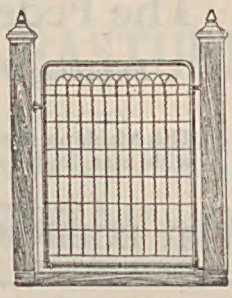

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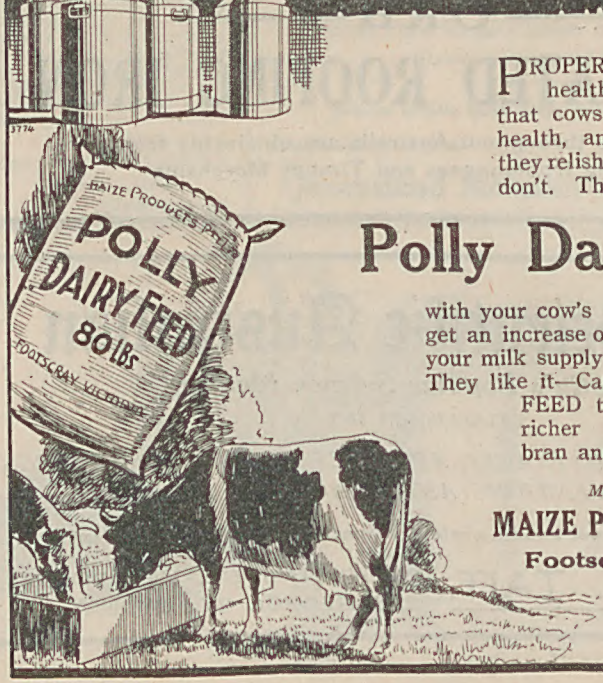

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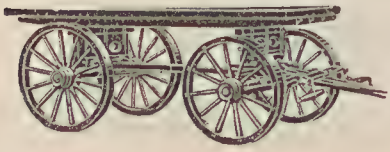

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NATIONAL MUSEUM, MELBOURNE

APRICOT GROWING.

(Continued from page 478.)

By W. H. Nicholls, Orchard Supervisor.

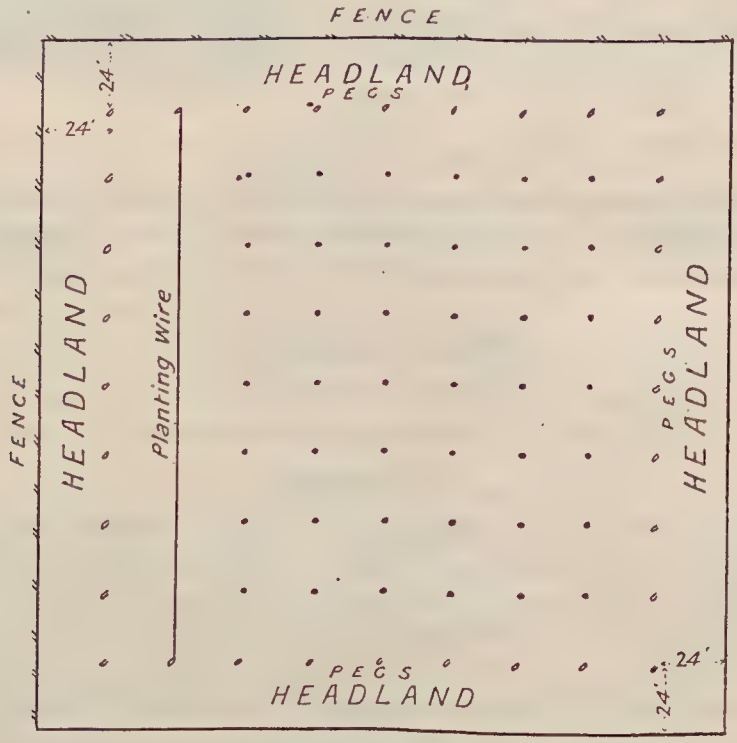
VI.—Planting.

One of the essentials, when the site has been determined, is to have the soil in the best possible condition to receive the young trees. It should be prepared by a deep ploughing in the spring, and a cross-ploughing, and if necessary sub-soiling, in the autumn. In the northern irrigation areas the preparation outlined is of great importance, more particularly on soils of a sandy-loam nature which have been irrigated for lucerne culture, &c., in order that the "hard-pan" usually found underlying such soils may be broken up. The roots of the young trees will thus be enabled to "plunge deep" into the moist sub-soil; this will ensure better root-systems to withstand any severe climate changes that may occur later on.

After having "squared" the block it will be found advantageous to "peg" it out. The distance between the rows should be not less than 24 feet, as the apricot grows into a large tree, and should be given plenty of room to spread.

For planting, the use of two marked wires is suggested; ordinary No. 12 gauge fencing wire marked with paint every 24 feet will serve the purpose, and if a ring be fixed in each end a bar may be used for tightening the wire. After measuring off 24 feet for a headland, the wire should be drawn tight parallel to the fence at one end, and when it is securely fastened pegs should be placed where wire is marked. The wire must then be moved to the opposite end and distances marked. The same thing is done at each side. The wire must then be moved in 24 feet, and the same procedure as before followed, and so on until the block is all pegged. By working in this manner, straight planting is ensured.

When the trees are received they should be carefully gone over, and all broken or damaged roots removed. A sharp knife being used for the purpose. If cut clean the wound will heal quickly, and invariably a cluster of fibrous roots makes from it. In addition to root pruning, it is also advisable to head back the trees if branches have been formed, or in the case of roots, to cut them back to 15 inches from the crown of the roots. Trees treated in the latter way are preferred mainly because of the facilities offered to form a well-set head.



Setting out the Trees.

The use of a planting board simplifies the work of planting when a block has previously been pegged out. A piece of softwood 3 ft. 6 in. by 4 in. by 1 in., cut as illustrated, is advised, and two peg holes should be cut in so as to allow the planting board to be easily lifted off. After placing the board in position and inserting the pegs in the holes made for the purpose it may be lifted off and the marking peg removed, so that the ground may be ready to receive the young trees. The board should then be put down again, and the tree put in the V cut (which is its correct position).

The roots should be placed so that they radiate in all directions: When filling in the earth around the tree some fine soil may be added—a little at a time. The tree should be gradually lifted so as to ensure the roots all being embedded, until the correct depth of the tree in the ground is obtained; then make the soil firm by tramping well. Should dry conditions obtain, it is advisable to water the trees in; a " basin " round the tree should be left for that purpose; it can be filled in later on. Avoid deep planting. The depth the tree was in the ground of the nursery rows is a good guide.

VII.—Irrigation and Cultivation.

One of the most important phases in the successful production of all fruits in the irrigated areas is the soil condition. To what extent a favorable soil condition is maintained by the use of water and by cultivation methods is too well known to need much repetition.

Unfortunately, many are prone to depend too much upon the application of water as a panacea for all agricultural troubles in dry districts. Often growers can be found applying large quantities of water to a block of trees simply because it has not been irrigated for some time. The question as to whether such applications are needed, apparently does not present itself.

So much depends on local conditions, both as regards the season, the nature of the soil and the methods of cultivation that it is practically impossible to determine the rate and frequency of watering.

As a general rule, however, two 4-acre inch waterings are ample to produce an apricot crop, and providing frequent and thorough cultivation is given, one 4-in. application after the crop is harvested will be found sufficient to carry to maturity the fruit buds for the following season.

The only profitable method of irrigation, as applied to orchards, is the furrow system. When we take into consideration the enormous loss of moisture by transpiration and evaporation, it is obvious that if an equable soil temperature is to be maintained, it is necessary to conserve as much moisture in the soil as possible, and this can be achieved only by a system of frequent and thorough cultivation.

The importance of maintaining an even soil temperature must be emphasized, for on this will depend the amount of fruit lost by " falling " at different periods during the maturing of the crop; it also controls sap flow to a great extent, and thus determines the size and quality of the fruit.

Irregular watering and cultivation affect the soil temperature—more especially irregular watering. It is often noticed that trees make good headway for a short period after an application of water, but this is not maintained unless sound principles of cultivation follow, for no matter what the moisture content of the soil may be, good results will not follow if the soil temperature is altered.

Eminent authorities on irrigation farming lay great stress on the matter of " chilling " the roots by allowing water to flow over a certain portion for too lengthy a period; so that in " setting out " furrows for irrigation, it is imperative to water only short sections at a time, in fact, one might say that twelve hours is the maximum time that water should be allowed to " flow over " any section. As soon as is possible after watering, the furrows should be closed in, so that the maximum amount of moisture may be retained in the soil. This operation must be followed by a complete cultivation immediately conditions permit.

A few days later, and at frequent intervals from them, this cultivation should be repeated, until such time as the trees require another "drink." The time for the second watering should be determined by the condition of the sub-soil; if it balls in the hand, sufficient moisture is present, and a cultivation then would be of greater benefit than irrigation. Unfortunately, water is often applied at this time, and the result is not satisfactory. In fact, generally speaking, one might say that too much water and too little cultivation is given.

Air is as necessary for the roots as water; therefore, avoid the flooding system altogether, as this excludes air, and causes the loss of humus in the soil. It is a lazy man's method; it is uneconomical, as loss by evaporation is greater by far than is the case when the furrow system is practised. If the soil is of a sandy nature the possibility of setting up an irrigation or hard pan is accentuated by flooding, as the weight of water carries down the pure sand particles, and deposits them on the unbroken sub-soil. Thus in the course of time an impervious layer is formed between the soils; this will not only make irrigation useless, but, in addition, will starve the roots beneath it. The writer's experience in the northern irrigation areas is that in practically all orchards which have soils of a sandy nature this irrigation pan is present. There is little doubt that the trouble has been accentuated by the application of water.

(*To be continued.*)

SPRAYING FOR THE CONTROL OF CHERRY APHIS.

Experiments are being conducted by the Horticultural Division in conjunction with the Science Branch for the purpose of controlling the Cherry Aphis.

On the 11th August last, sixteen trees were sprayed at Mr. Hardidge's orchard at Croydon. Eight trees were sprayed with Red Oil (Vacuum) only, at a strength of 1 in 20, and eight were sprayed with the same strength emulsion plus Nicotine Sulphate at the rate of ¾ pint to 80 gallons. Two trees were left in the middle of the rows as a check.

The trees were examined on the 21st August and the aphis eggs on the sprayed trees appeared to have changed to a rusty brown colour and were mostly shrivelled. On the 15th October the trees were again examined. There was no appreciable difference between the trees sprayed with oil only and those sprayed with oil plus Nicotine Sulphate. There was, however, a marked difference between the sprayed and unsprayed trees. The check trees were rather badly affected with aphis. Those sprayed, while not entirely free, had only a few leaves affected.

An adjoining row of trees was sprayed by Mr. Hardidge about a fortnight later with Vaccum Red Oil, 1 in 25. These, while slightly cleaner than the unsprayed trees, were not nearly so free from aphis as those sprayed earlier with the stronger emulsion. It would appear from the above that, to destroy the eggs, a strength of at last 1 in 20 is required, and that the oil should be applied before the aphis hatch; also, that at this time, the addition of nicotine is of no value.

On the 18th October the trees were sprayed with nicotine and soap, and some with a patent preparation.

These experiments are being continued, and further reports will be published in this *Journal* as they become available.

WHEAT AND ITS CULTIVATION.

(Continued from page 614.)

By A. E. V. Richardson, M.A., D.Sc., Agricultural Superintendent.

IX.—WHEAT IMPROVEMENT.

One of the most remarkable and interesting features of modern agriculture is the extraordinary activity displayed in the subject of plant improvement throughout the world.

This activity is largely due to the rediscovery of Mendel's work by De Vries, Tschermak, and Correns, the epoch-making work of De Vries on the mutation theory, and the stimulus given through the establishment of schools of genetics in the older universities of the world.

Practically every agricultural crop of importance has been subjected to a critical study, with a view of determining the best lines on which specific and desirable improvements may be brought about.

Systematic plant-breeding is a comparatively modern development. The reason is not far to seek. From the dawn of civilization, man's attention has been occupied with the improvement of his animals rather than his crops. Indeed, improvement in plants was hardly possible until sexuality of plants was discovered, and the necessity of pollen in seed formation became known and generally understood. This discovery was made only in 1691 by Camerarius, and nearly half a century elapsed before the structure of the flower was properly appreciated.

Thus, while systematic mating of plants could not have been practised for more than two centuries, the control of the breeding of animals has been undertaken by man for thousands of years.

Though the practice of plant-breeding is quite a modern development, the amount of data already collected is sufficient to indicate that enormous possibilities lie ahead of this line of work.

The great improvements wrought in our flocks and herds by careful, systematic breeding is apparent to the veriest novice. The development of the milking and beef types of Shorthorn cattle, the American trotting horse, and the Australian type of Merino sheep may be taken by way of illustration. No one nowadays expresses the least surpise if a breeder of dairy cattle attempts to breed a herd giving heavy yields of butter-fat. It is so common a phenomenon that it ceases to cause wonder.

But to set out with the definite intention of breeding farm crops, with the object of improving them in certain specific qualities, is still considered unusual enough to occasion surprise. The fundamental principles of breeding and inheritance, however, are the same, whether they are applied to animals or to plants. Is it not perfectly rational then to assume that profound changes may be wrought in the vegetable world by the application of those principles of breeding which have

brought individual flocks and herds to the high pitch of excellence of the present day?

Fig. 39.—Method of Preparing Ears of Wheat for Hybridising.

A—Typical Ear. B—Upper and lower spikelets suppressed and two flowers retained on each spikelet.

The plant-breeder has at least one immense advantage over the animal-breeder.

He may work with hundreds of thousands of individuals, and can afford to make his selections with the utmost rigour, and take full advantage of variations of type, which are the basis of improvement.

The animal-breeder, for many reasons of which not the least is the expense incidental to breeding and feeding of large numbers, must, of necessity, confine his attention to comparatively few animals, and the probabilities of securing wide and valuable variations are thereby considerably lessened.

The possibility of improving plants depends on (1) variation, (2) heredity. Unless variations occurred no improvement would be possible; unless some variations were transmitted from parent to offspring no improvement would result.

Plant breeding has been established on a firm scientific foundation through the work of Mendel and his followers. The unit characters which compose the mosaic of the individual are transmitted in accordance with a definite scheme of inheritance. The objective of the plant-breeder is to combine in one individual the desirable unit characters of two or more individuals. By cross-breeding the unit characters of any two individuals are combined in impure (heterozygous) form in the first generation. If this first generation progeny are self-fertilized, the progeny of the second generation of plants will contain all possible combinations of unit characters present in the two parent plants. From the second generation progeny forms containing the desired combination of characters may be isolated as pure-breeding types (homozygous types) with absolute certainty.

The rôle of selection and hybridization in plant-breeding has been clearly demonstrated by modern research in plant-breeding.

Two important points cover the rôle of selection:—(1) Nature is continually producing variations due to (*a*) environment, (*b*) variation in gametes or germ cells of the individual. We have reason to believe former variations, i.e., those induced by the plant's environment, are not inherited. The latter variations, i.e., those due to variations in the germ cells, are inherited, and form the basis of selection. (2) The function of selection is the isolation of desirable heritable variations among the useful plants, and through them a race with the desired characters. Selection is therefore preservative, not creative in character.

Cross-breeding, on the other hand, is truly creative, for the plant-breeder may combine into one plant the unit characters of two or more plants, thus creating a new combination which may not hitherto have existed.

Development of Scientific Methods of Breeding.

There is a close relationship between the development of theories of evolution and the development of scientific methods of breeding. Consider the discoveries of Darwin, Weismann, De Vries, and Mendel.

1. Darwin's Theory of Natural Selection.

The fact of evolution—that new species arise by a modification of pre-existing species—is indisputable, and is supported by innumerable facts of classification, morphology, embryology, and by the geographical

distribution of plants and animals and their succession in the geological strata. The explanation of evolution, however, is not yet quite satisfactory.

Darwin based his theory on the following facts:—(*a*) Variability; (*b*) Struggle for existence; (*c*) Natural selection; (*d*) Heredity.

(*a*) *Variability*—

No two plants and no two animals are absolutely alike. To the man in the street each member of a large flock of merino sheep seems precisely the same as each other member of the flock. To the shepherd or enthusiastic stock-breeder, however, each sheep possesses certain peculiarities and attributes which distinguish it from every other sheep in the flock. Plants likewise are variable.

Usually the variations from plant to plant are small. Occasionally quite large variations or departures from type are observed without any apparent reason. These large variations are usually stable, and are inherited. De Vries calls them mutations. Darwin observed these "sports," but he considered that they were relatively unimportant in the origin of species because they occurred infrequently. The small fluctuating variations, he considered, were all-important in evolution, and were the material on which natural selection operated. The individuals of a species differ then from one another, and these increase or decrease their chances of survival in the struggle for existence.

(*b*) *Struggle for Existence*—

If all the seeds produced in a year by a given species were to germinate, there would be far too many plants to reach maturity. A fierce struggle for existence results between individuals of the species, and the fittest survive and the unfit perish. If the individual members of a species were all identical we could only ascribe to blind chance the fact that some survive whilst others perish. But they are not alike. Some plants are hardier and stronger than others. Some have a well-developed root system which enables them to get nourishment where others fail. The slightest difference among plants may mean the difference between life and death, and it is this fact which enables Nature to continue her selection. The weaker individuals are forced to the wall in the struggle for existence, whilst the stronger survive. As Darwin says, "Those plants, in the long run, survive which are best able to adapt themselves to their environment." In other words, those individuals survive which vary in such a way as to give them some advantage over their less fortunate neighbours. Hence this struggle for existence results in natural selection.

(*c*) *Natural Selection*—

The fittest individuals survive and leave progeny, the unfit perish. The forms which survive possess characters better adapted to a given environment, and therefore these forms have an advantage over others in the struggle for existence.

(*d*) *Heredity*—

According to Darwin, the variations which survive in this struggle for existence are perpetuated by heredity. Thus variation produces the material on which natural selection operates, and heredity tends to perpetuate the variations.

Darwin did not explain the cause of these variations, or the mechanism by which the variations were transmitted. He recognized that there were were two kinds of variations—(1) the chance, or "fortuitous" variations, which caused every plant to be different from its neighbours, (2) discontinuous variations, or "sports"; but he considered the former of primary importance in evolution.

2. De Vries' Theory of Mutation.

De Vries attacked the question of the kind of variation which furnished the material for evolution. He affirmed that the small continuous variations were of slight value in evolution, and advanced the hypothesis that the large, discontinuous variations, i.e., "sports," "mutations," furnished the basis for evolution.

According to this view, species are not slowly and gradually changed into new forms, but new and distinct types arise suddenly from the parent form. The variety as a whole continues unchanged, but produces from time to time aberrant individuals or mutations which breed true to type, and are the real source of all progress. He based his theory on the peculiarities of certain seedlings of the Evening Primrose (*Oenothera Lamarckiana*) which he found growing wild at Hilversbun, in Holland, and the large body of evidence which he brought forward did much to convince biologists that discontinuous variations were far more common than was formerly supposed.

We now know that "sports," "mutations," or discontinuous variations are frequent, and they are remarkably stable, and breed true to type. As Thomson says, "Proteus leaps as well as creeps."

Examples of mutations are the five-leaved clover (obtained by De Vries from cultures of a four-leaved clover), the Shirley Poppy, Star Primrose. In 1880 the vicar of Shirley noticed a variant of the common field poppy, and made it the ancestor of a distinctive type. The Star Primrose (*Primula stellata*) arose as a sport from the conventional Chinese primrose, and was raised by Sutton and Co. into a favorite stock.

The mutation theory does not deny the importance of selection as a means of improving agricultural plants, for even if a mutation does appear it may still be improved in its lesser features by careful selection.

3. Weismann's Theory of Germ Plasm.

Weismann's contribution to the study of evolution was the contrast he made between the germ cells and the body cells. He assumed that there was a sharp cleavage between the body cells (somato plasm) and the reproductive glands (germ plasm). The individual is merely a carrier for the essential germ plasm whose properties have been

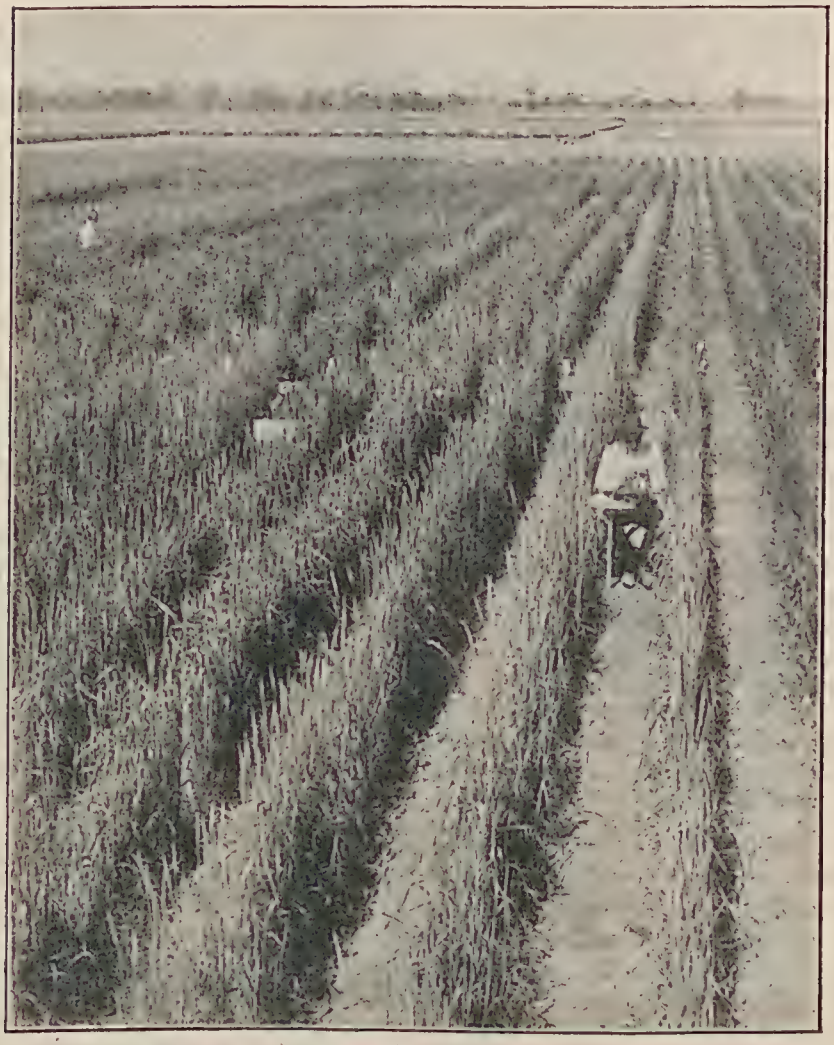


Fig. 40.—View of Cross-bred Cereal Plots, Rutherglen.

determined long before he was capable of living a separate existence. As Wilson puts it, "The child inherits from the parent germ cell, not from the parent body, and the germ cell owes its characteristics, not to the body which bears it, but to its descent from a pre-existing germ cell of the same kind. Thus the body is, as it were, an offshoot from the

germ cell. As far as inheritance is concerned, the body is merely the carrier of the germ cells which are held in trust for coming generations."

This conception of the isolation of the germ cells from somatic influences is in complete accordance with the Mendelian view of the inheritance of definite characters. It was Weismann who first emphasized the belief that the chromosomes represent those parts of the nucleus which are specially concerned in the processes of heredity.

Weismann denied that modifications brought about in the individual during its lifetime through varying conditions of nutrition and environment could be transmitted to the offspring. Therefore, acquired characters are not inherited. In order that a new character may be produced, there must be a modification of the germ plasm.

4. Mendel's Law of Heredity.

The law which Mendel formulated is regarded as the greatest of biological discoveries. It furnished the starting point from which the modern study of genetics has developed, and provided a scientific basis for plant-breeding. He sought to discover the law of inheritance in hybrid varieties in peas, and concentrated his attention on the mode of transmission of unit pairs of characters, e.g., tallness and dwarfness, through several generations.

Mendel communicated the results of his now world-famous experiments to the local scientific society in 1865, but, strangely enough, they lay unnoticed until 1900, when they were rediscovered and independently confirmed by De Vries, Correns, and Tschermak.

Mendel realized that the failure of the early hybridizers to elucidate the general principle of inheritance from the results of cross-breeding was due to the fact that they did not concentrate their attention on definite characteristics of the plant, and trace the inheritance of these characteristics through a sequence of generations. After a great deal of experimenting he decided to use the common pea for his investigations. A close examination of the different varieties in cultivation enabled him to separate 22 distinct types. He arranged these pure races into pairs of opposite or contrasting characters and crossed representative plants of each pair separately. Thus he crossed tall peas with dwarf peas, peas with angular seeds with those possessing rounded seeds, &c. He carefully preserved all the progeny of every cross-bred plant and planted them *separately* each year. In the case of the cross between the tall and the dwarf pea, the progeny of the first generation were all talls. This property or character of tallness, Mendel, therefore, described as dominant, whilst the opposite attribute dwarfness, which appeared to be masked, he described as recessive. The plants of this generation were allowed to fertilize themselves, and the offspring of each plant were separately sown. In the second generation it was found that one-quarter of the progeny regularly resembled the recessive parent, and constantly bred true to type. The remaining three-quarters of the progeny resembled the dominant parent. That is to say, there were three times as many talls as there were dwarfs in the second generation of the hybrid. It was found that the recessives bred true to type for countless generations, i.e., they always gave rise to plants

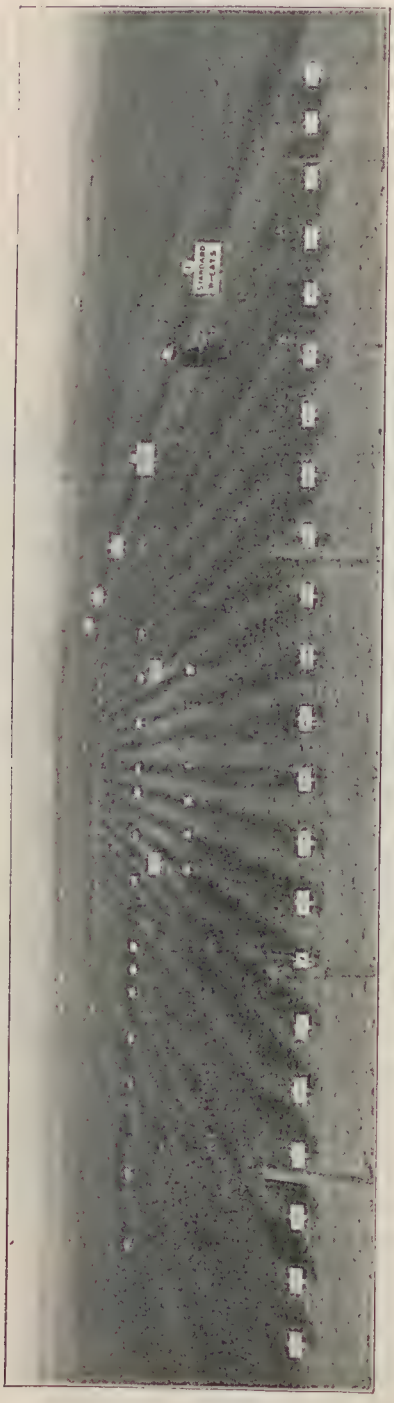


Fig. 41.—View of Standard Wheat and Cross-bred Cereal Plots, Werribee.

that were dwarf in character. The dominants, however, when allowed to fertilize themselves, did not all breed true, but gave rise to plants of two kinds—

(*a*) *Impure* dominants which in the next generation gave a mixture of both talls and dwarfs in the proportion of three talls to one dwarf.

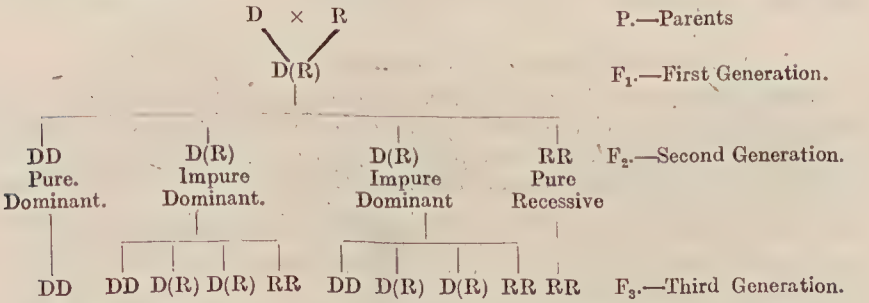
(*b*) *Pure* dominants which produced talls only, and were thus pure to tallness.

Moreover, statistical examination of these two types revealed that there were *exactly twice* as many impure dominants as there were pure dominants. In other words, the second generation of the original hybrid consisted of three different types of plants.

Pure Dominants, 25% — Impure Dominants, 50% — Recessives, 25%

3 Dominants 1 Recessive

These interesting results obtained by crossing the tall and the dwarf peas may be summarized by the following diagram, where D represents a true breeding tall plant—the Dominant character, and R the Recessive character, a pure breeding dwarf plant; and D(R) an Impure Dominant, i.e., a tall which on self-fertilization gives both talls and dwarfs in the ratio of 3 : 1.



Besides tallness and dwarfness other contrasted pairs of characters were experimentally dealt with, and it was found that they followed the same law of inheritance. Thus coloured flowers were found to be dominant to white, and the first generation consisted of coloured flowers. In the second generation there were three times as many coloured flowers as white. The white flowers were found to breed true to type, but of the coloured flowers the ratio of pure types to impure types was as 1 : 2.

One naturally wonders what would happen if two plants possessing two pairs of contrasting characters were crossed together. For example, suppose a tall pea with coloured flowers was crossed with a dwarf pea with white flowers, how would the respective characters be distributed in the progeny? In this Mendel found that each pair of characters followed the same rule, and that the inheritance of each was quite independent of the other.

When the tall coloured pea was crossed with the dwarf white pea, the progeny of the first generation were all tall coloured plants, for

tallness was dominant to dwarfness, and coloured flowers were dominant to white.

When this hybrid was self-fertilized the second generation gave four kinds of plants, namely, coloured talls, coloured dwarfs, white talls, white dwarfs. Further, it was found that the plants with coloured flowers were three times as numerous as those of the plants with white flowers. Similarly there were three times as many talls as dwarfs. In this generation, the four forms were actually found to be present in the following ratios, namely:—

9 coloured talls, 3 white talls, 3 coloured dwarfs, 1 white dwarf.

And this is the only ratio which can satisfy the condition that the coloured should be to the white as 3:1, and at the same time the talls should be to the dwarfs as 3:1. These results may be concisely summarized as follows:—

When two plants exhibiting two pairs of contrasting characters are crossed together, the progeny of the first generation consists of plants bearing the two dominant characters, whilst in the second generation the characters segregate with the following proportion:—Nine plants possessing the two dominant characters; three plants exhibiting one dominant and one recessive; three plants exhibiting the other dominant and the other recessive; and only one plant with both the recessive characters. This principle may be extended to three or more pairs of different characters.

What was Mendel's Explanation of these Facts?

After Mendel had experimentally determined the scheme of inheritance for each of the seven pairs of differentiating factors which engaged his attention, he attempted to provide a theoretical interpretation to fit in with the observed facts. He assumed in the first place that each germ cell or gamete could carry a factor which could give rise to one or other of the differentiating pair of characters, e.g., any given germ cell could carry the attribute or factor either for tallness or for dwarfness, but *not for both.*

These two attributes were mutually exclusive so far as the gametes are concerned. When a pure tall plant produced gametes or germ cells each bore the attribute for tallness. Similarly the gametes of the dwarf plants all bore the attribute of dwarfness. When the tall pea is crossed with the dwarf pea a gamete bearing the attribute of tallness mates with a gamete bearing the attribute of dwarfness. Inasmuch as the attribute of tallness is dominant, the hybrid progeny will be in appearance similar to the pure tall plant. This hybrid tall, however, will differ markedly from the pure tall plant when it produces gametes, Mendel assumed that when it forms gametes or germ cells the elements representing tallness and dwarfness segregate from one another, and of the total number of gametes formed one-half contains the one element, and one-half the other. That is to say, when this hybrid plant forms its germ cells—pollen grains and egg cells—one-half of the pollen grains will possess the dominant character, and one-half the recessive character. Similarly one-half of the egg cells (ovules) will carry the dominant attribute, and one-half the recessive.

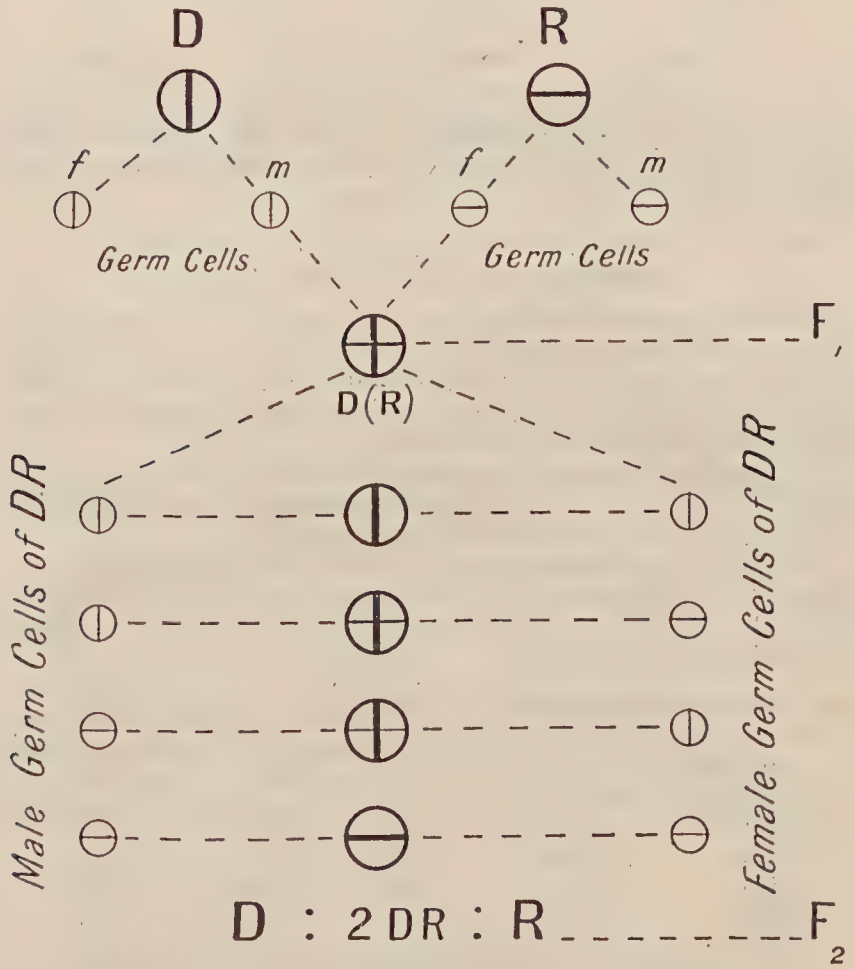
Obviously, if this hybrid plant is self-fertilized there are four and only four combinations possible, namely:—

(*a*) A dominant pollen grain with a dominant egg cell. DD.
(*b*) A dominant pollen grain with a recessive egg cell. DR.
(*c*) A recessive pollen grain with a dominant egg cell. DR.
(*d*) A recessive pollen grain with a recessive egg cell. RR.

and the proportion of each must be:—

DD: 2DR: RR.

which corresponds to Mendel's Law.



Illustrations of Mendel's Law with Cereals.

Many examples of the operation of Mendel's Law might be quoted from the wheat-breeding work at the State Research Farm, Werribee. We will consider a few of many cases which might be cited, taking as illustrations crosses in which one, two, and three pairs of unit characters are involved.

Monohybrid Segregation.

A cross was effected in 1912 between Bunyip (white chaff, r) and Federation (red chaff, R). All plants in the first generation had red chaff indistinguishable from Federation. In the second generation 1,458 plants were raised from four families with the following result:—

	Red chaffed plants.	White chaffed plants.	Total.
Family 1 ..	314 ..	97 ..	411
Family 2 ..	212 ..	71 ..	283
Family 3 ..	352 ..	108 ..	460
Family 4 ..	222 ..	82 ..	304
	1,100 ..	358 ..	1,458

The proportion of red chaffed to white chaffed wheats was thus 3.08 to 1, which is closely in accord with what might be expected from Mendel's Law.

Dihybrid Segregation, i.e., Involving Two Pairs of Characters—Inheritance of Chaff Colour and Awns.

For the purpose of investigating the inheritance of two characters in wheat, a cross was made between two pure lines of Indian H (bald, red, BR) and King's Early (bearded, white, br.). Indian H possesses dark bronze-coloured chaff, and is devoid of awns; King's Early has creamy white chaff and long coarse awns.

Six crossbred plants were obtained in the first generation, and the seeds of each plant were sown in separate rows in the second generation. One plant was kept as a specimen for reference.

The second generation of plants gave four distinct types of plants—bald red (BR), bearded red (bR), bald white (Br), and bearded white (br). The numbers of phenotypes from each cross in the second generation were as follows:—

Table Showing Segregation of Plants in Second Generation from a Dihybrid Cross between Indian H (BR) and King's Early (br).

No. of Cross.	Bald Red.	Bearded Red.	Bald White.	Bearded White.
2001	292	89	91	30
2002	166	53	77	32
2003	192	53	59	17
2005	34	14	14	4
2006	47	13	17	5
Totals	731	222	258	88

The segregation for the separate characters was as follows:—

Red, 951; white, 346—ratio, red to white, 2.73 to 1.

Bald, 990; bearded, 310—ratio, bald to bearded, 3.17 to 1.

The segregation of these crosses was sharp and distinct. The four characters present in this cross segregated approximately in the ratio of—9 Bald Red, 3 Bald White, 3 Bearded Red, 1 Bearded White.

These results may be illustrated in the following way—

Pollen (Male) Parent	×	Ovule (Female) Parent
Indian H		King's Early
(Bald Red)		(Bearded White)
BR		br

Bb Br ... ... First Generation

When a plant of this constitution forms germ cells there are four possible types of pollen grains, and four possible types of ovules, namely, BR, Br, bR, br. Now, each of these four types of ovules may unite with any one of the four types of pollen grains, making sixteen possible combinations. These combinations may be represented by the following diagram—

A D

BR BR (Bald Red)	BR Br (Bald Red)	BR bR (Bald Red)	BR br (Bald Red)
Br BR Bald red	Br Br Bald White	Br bR Bald red	Br br Bald White
bR BR Bald Red	bR Br Bald red	bR bR Bearded red	bR br Bearded red
br BR Bald red	br Br Bald white	br bR Bearded Red	br br Bearded White

B C

From this diagram it is clear that the only possible combinations of gametes concerned in this cross are:—

9 Bald Red, 3 Bald White, 3 Bearded Red, 1 Bearded White.

Only four of these combinations will breed true to type, namely, those lying on the diagonal AC. The constitution of these plants is as follows:—BBRR, BBrr, bbRR, bbrr. It will be observed that they are pure, both on the male and female side for each of the two characters they contain. They are, therefore, *homozygous*, and must breed true to type. The other twelve combinations will be *heterozygous*, i.e., impure for one or both the characters they contain. Therefore, they will be impure breeding forms, and in the next generation they will segregate.

Dihybrid Segregation with Barley.

An illustration of dihybrid segregation with a cross between Pryor and Skinless Barley is shown in Fig. 44. Pryor is a bearded, two-rowed barley; Skinless is a bald, six-rowed type.

All the progeny in the first generation were bald and two-rowed, whilst in the second generation four types were obtained in the following proportions:—9 bald, two-rowed; 3 bearded, two-rowed; 3 bald, six-rowed; 1 bearded, six-rowed.

Trihybrid Segregation, i.e., Crosses with Three Pairs of Characters.

A cross was effected at Werribee, between Red Winter Spelt (*Triticum spelta*) and Telfords (*Triticum vulgare*). The two species differed in three sharply defined characters—red and white chaff, smooth and hairy chaff, lax and dense ears.

Spelt possessed long lax ears and smooth red chaff (RwL). The ear of Telfords was dense, and the chaff white and woolly (rWl). The average rachis length per spikelet was for Spelt, 12.8 m.m.; Telfords, 6.6 m.m.

The first generation plants were all red, with hairy chaff and lax ears. 314 plants were obtained in the second generation, and they segregated as follows:—

Red, woolly, lax	(RWL)	144
Red, non-woolly, lax	(RwL)	45
White, woolly, lax	(rWL)	45
Red, woolly, dense	(RWl)	34
Red, non-woolly, dense	(RWl)	10
White, woolly, dense	(rWl)	17
White, non-woolly, lax	(rwL)	14
White, non-woolly, dense	(rwl)	5
		314

The theoretical expectation for a Trihybrid ratio from 320 plants derived from a crossbred parent of constitution Rr, Ww, Ll, would be a segregation in the second generation as follows:—

135 RWL, 45 RwL, 45rWL, 45 RWl, 15Rwl, 15 rWl, 15rwL, 5 rwl.

The actual numbers obtained from 314 plants were:—

144 RWL, 45 RwL, 45 rWL, 34 Rwl, 10 Rwl, 17 rWl, 14 rwL, 5 rwl.

When two plants differing in three pairs of characters, Aa, Bb, Cc, are crossed together, the first generation progeny are alike and show

all three dominant characters. In the second generation the segregation is as follows:—

27 ABC, 9 ABc, 9 aBC, 9AbC, 3 Abc, 3 aBc, 3abC, abc.

Of the 64 possible combinations, only eight will breed true to type.

Crosses Involving Four Pairs of Characters.

In 1914 an outstanding example of natural cross-fertilization with barley was observed at Werribee. In a pure line of Skinless barley (six-rowed, bald, hull-less) two plants with bald, two-rowed ears and hulled grain were observed. These plants were remarkable in that none of the two-rowed types of barley previously grown possessed bald ears. The seeds of these two plants were sown in 1915, and segregated into four distinct groups with respect to awns and the number of rows. The four types were bald two-rowed, bearded two-rowed, bald six-rowed, bearded six-rowed. In each of these classes were plants with lax and dense ears, and hulled and hull-less grain.

As the whole row of skinless barley plants came from one ear, it was obvious that two of the grains must have been naturally cross-fertilized with pollen possessing the gametes for bearded, two-rowed, lax ear, and hulled grain, i.e., an ordinary malting barley, such as Pryor, since the skinless form was bald, six-rowed, hull-less, dense (Bthl). The first generation plant was evidently Bb, Tt, Hh, Ll, in constitution. Thirty-seven plants were grown separately in the second generation.

The main objective was to isolate a beardless, two-rowed, dense, hulled type, suitable for malting purposes, and a bearded, six-rowed, hull-less form for feed purposes. Incidently, the mode of segregation of each of the 37 forms was observed in the second generation.

Sixteen perfectly distinct, pure breeding types were obtained from this cross, some of which were isolated in the third generation, and the remainder in the fourth generation. The sixteen types, with approximate ratios in which they segregated, were as follows:—

Bald, two-rowed, hulled, lax	(BTHL)	81
Bald, two-rowed, hulled, dense	(BTHl)	27
Bald, two-rowed, hull-less, lax	(BThL)	27
Bald, six-rowed, hulled, lax	(BtHL)	27
Bearded, two-rowed, hulled, lax	(bTHL)	27
Bald, two-rowed, hull-less, dense	(BThl)	9
Bald, six-rowed, hulled, dense	(BtHl)	9
Bald, six-rowed, hull-less, lax	(BthL)	9
Bearded, six-rowed, hulled, lax	(btHL)	9
Bearded, two-rowed, hull-less, lax	(bThL)	9
Bearded, two-rowed, hulled, dense	(bTHl)	9
Bald, six-rowed, hull-less, dense	(Bthl)	3
Bearded, two-rowed, hull-less, dense	(bThl)	3
Bearded, six-rowed, hulled, dense	(btHl)	3
Bearded, six-rowed, hull-less, lax	(bthL)	3
Bearded, six-rowed, hull-less, dense	(bthl)	1
		256

These are the proportions in which a cross involving four pairs of characters segregate in the second generation.

The relationship between the number of pairs of factors, number of gametes, number of combinations of gametes, number of pure breeding and impure breeding forms is shown in the following table:—

TABLE XXII.—SHOWING THE PROPORTIONS EXISTING BETWEEN GAMETES, ZYGOTES, PURE AND IMPURE BREEDING FORMS, IN MENDELIAN EXPERIMENTS.

Number of pairs of factors	1	2	3	4	n
Number of different gametes ..	2	4	8	16	2n
Number of combinations of gametes	4	16	64	256	4n
Number of pure-breeding forms (Homozygotes) in second generation	2	4	8	16	2n
Number of impure-breeding forms (Heterozygotes) in second generation	2	12	56	240	4n–2n

Fig. 42.—Natural Cross in Barley. Plant (Bald two-rowed lax) found in Skinless Barley (Bald six-rowed dense.)

GRASS TUFT WHEATS.

Small dwarf plants, 6 in. to 8in. high, with numerous narrow foliage leaves (Fig. 45), are occasionally found in the second and subsequent generations in certain crossbred wheats. These plants appear most frequently when certain Indian wheat varieties are crossed with Australian crossbred wheats. As these grass tufts rarely form developed ears and fertile seed, it is not possible to make a detailed study of the mode of inheritance of this dwarf character.

The inheritance of these dwarf forms is of little practical importance, as such wheats would be of small value, even if they reproduced normally. It is possible, however, that a study of the inheritance may throw light on the probable nature of the early progenitors of our cultivated wheats. The appearance of such grass tufts in the segregating generation of certain crossbred wheats may be due to a form of

reversion, brought about by crossing, and it is reasonable to assume that the appearance of these tufted forms is due to the accidental meeting in the zygote of complementary factors long parted in the evolutionary process. Many cases of the appearance of tufted wheats have been observed at Werribee, but in every case the formation of grass tufts has been brought about when widely different varieties are crossed, and particularly when certain Indian varieties are hybridized with Australian wheats of crossbred origin. No cases have been observed of grass tufts in pedigree cultures or pure lines of any of the several hundred standard varieties grown in the stud cereal plots.

When Indian 5, Indian H are crossed with certain varieties, e.g., Jonathan, Federation, and King's Early, grass tuft forms are invariably met with in F_2 and succeeding generations. The proportions in which these grass tuft forms appear are by no means constant, and as they rarely form fertile seed, it is difficult to proceed far in studying the inheritance of these forms.

The segregation of grass tufts to normal wheat plants in the second generation was studied in three crosses. The results were as follows:—

TABLE XXIII.—SHOWING PROPORTION OF GRASS TUFT TO NORMAL WHEAT PLANTS IN THREE F_2 CROSSBRED WHEATS.

Cross.	Number of Plants—		Ratio—	
	Normal.	Grass Tufts.	Normal.	Grass Tufts.
King's Early x Indian 5	1,669	302	5.6	1
Federation x Indian 5	1,569	163	9.6	1
Gluyas x Indian 5	816	106	7.7	1

One case was of special interest. When Jonathan was crossed on Indian F, all plants in F_1 were grass tufts (*vide* Fig. 45). This plate shows the F_1 plants, with the male plant (Jonathan) at the head of the row, and the ovule parent (Indian F) at the bottom of the row, with ten F_1 crossbreds, all grass tufts between the two parents. Four of these tufts produced seed and in F_2 gave the following result:—

TABLE XXIV.—SHOWING SEGREGATION IN F_2 OF NORMAL AND GRASS TUFT WHEATS FROM JONATHAN X INDIAN F CROSS.

Grass Tuft.	No. of Grains Produced.	No. of Mature Plants.	Segregation of Mature Plants—		
			Normal Red Chaff.	White Chaff.	Grass Tufts.
1	100	50	24	7	19
2	98	53	29	8	16
3	37	31	12	4	5
4	72	55	18	7	30
Totals ..	307	179	83	26	70

Thus the ratio of normal to grasstuft forms was approximately 11 to 7.

Dominant and Recessive Characters in Wheat.

During the past twelve years the inheritance of unit characters has been studied in a large number of crosses at the Werribee, Longerenong, and Rutherglen State Farms. Twenty-one varieties of wheat were used in these studies.

The varieties used were Spelt (*T. spelta*); Indian 5, Indian 6 (*T. sphaerococcum*); Huguenot (*T. durum*); Clubhead (*T. compactum*); Bayah, Bunyip, Canberra, Comeback, Dart's Imperial, Federation, Genoa, Gluyas, Indian F, Indian H., Jonathan, King's Early, Telfords, Thew, and Yandilla King (*T. vulgare*). Pryor, Oregon, Skinless, and Gatami barleys were also used.

The behaviour of the crosses in the first and second generations was observed, and a statistical examination made of the F_2 segregates. As a result of this work the following characters were found to be dominant and recessive in wheat and barley:—

	Dominant.	Recessive.
Wheat—		
	Brown or red chaff	White chaff
	Black chaff (Medeah, Huguenot)	White chaff
	Beardless ears	Bearded ears
	Pubescent chaff	Glabrous chaff
	Lax ear	Dense ear
	Hollow straw	Solid straw (Huguenot, Medeah)
	Early maturity (in *T. vulgare*)	Late maturity (in *T. vulgare*)
	Red grain	Light yellow grain
Barley—		
	Coloured chaff (Black)	White chaff
	Beardless ears	Bearded ears
	Hulled grain	Hull-less grain
	Two-rowed form	Six-rowed form
	Lax ear	Dense ear

In hybrids between *T. vulgare* and *T. durum,* intermediate forms were found in F_2 for period of maturity. In hybrids between red spelt and yellow seeded forms of *T. vulgare,* dark red, intermediate red, and yellow grains were obtained in F_2. In crosses between *T. sphaerococcum* (dense eared Indian wheats) and lax eared forms of *T. vulgare,* lax and dense ears segregated sharply in F_2.

In some crosses between *T. compactum* (Clubhead) and *T. vulgare,* laxity of ear was intermediate in F_1, and lax, intermediate and dense eared forms approximately in the proportion of 1 : 2 : 1 were obtained in F_2. In crosses between Huguenot (solid straw) and Yandilla King (hollow straw) the segregation of solid and hollow straws was sharp and well defined.

Value of Mendel's Work.

Mendel's results have been confirmed by many workers in widely different fields of investigation. His law is a great contribution to evolution and to the science of breeding.

One great advance has been made possible by his discovery. The individual may be regarded as built up of so many definite unit

characters, each of which is independently inherited in accordance with a definite scheme. The final character of an organism depends on the number of factors existing in the two gametes responsible for its formation.

The Darwinian account of the Origin of Species assumed that variation was continuous, and that any variation could be transmitted to the off-spring. Neither of these assumptions is justified. Bateson and De Vries have shown how prevalent discontinuous variation is in nature, and Mendel and his followers have shown that heritable variation has its basis in the gametes. From the stand-point of Cytology we may regard the chromosomes of the nucleus as the bearers of the heritable factors. The number of chromosomes for each species is constant, and the form and individuality is characteristic. Thus, in maize, the cells contain twenty chromosomes, whilst wheat contains sixteen, and tobacco 48. In man there are 48 chromosomes. Each chromosome is supposed to be composed of chromomeres and each chromomere may be the seat of the heritable factors.

The gametes are discontinuous, and therefore the zygotes formed by the union of the two gametes must necessarily be discontinuous. Natural selection does not create a new variation, because this is decided by the presence of certain definite factors in the gamete. Natural selection merely decides whether the new type is to survive or to be eliminated.

We may ask how on this hypothesis can we account for the infinite variety of forms in nature?

The presence or absence of a comparatively small number of factors carried with it the possibility of an enormous range of variation. Thus, with six pairs of character differences, there would be 2^6 or 64 distinct phenotypes.

If the heterozygous form is distinguishable from the homozygous form there are three possible forms for each factor, and for six pairs of factors there would be 3^6 or 729 phenotypes. The almost infinite variety in nature can therefore be accounted for by assuming the presence or absence of a comparatively small number of factors. The Mendelian conception of unit characters based on specific characters transmitted in accordance with a definite scheme of inheritance is of great service to the plant breeder. The breeder is ever seeking to improve the type of organism with which he is working. His final objective is the production of a type which will combine the greatest number of desirable properties with the least number of undesirable ones. The desirable characters may be distributed amongst two or more plants. His task is to unite all these desirable characters into one variety. Before he can do this he must determine the inheritance of the factors upon which these characters depend. Once these factors have been determined, they can be brought under control and associated or disassociated at the breeders' will. He may combine in one plant the unit characters of two or more plants and thus create a new combination or variety. The main object of hybridizing is the shuffling of the unit characters in the first hybrid generation, and their recombination in the second generation.

In crossing plants differing in several unit characters the plant breeder is now certain of two things.

(1) With a sufficient number of progeny in the second generation every possible recombination of the characters present will be represented by at least one pure specimen.

(2) These pure types when self-fertilized will breed true.

Development of Wheat Breeding.

Le Couteur, Shirreff, Hallett, Vilmorin, and Rimpau were amongst the most notable of the early wheat breeders. Le Couteur[1] during the early part of last century isolated from a field of wheat 23 distinct types, one of which, Bellevue de Talavera, was extensively grown. He was the first to discover the importance of selecting *individual plants* in the improvement of cereals. It is of interest to note that Le Couteur selected from one of his plots a red, velvet-chaffed (pubescent) wheat. Among the progeny he found there were plants with red velvet, red smooth, white velvet, and white smooth chaff, and on counting the number of ears of each he found there were 200, 21, 86, and 43, respectively, of each kind. His explanation was as follows:—"The parent ear having been discovered in a field of mixed white corn had been impregnated with the pollen of four different sorts of wheat."

Patrick Shirreff[2] searched his fields for exceptional plants as starting points of new varieties. He succeeded in producing seven new varieties, all of which were extensively grown in his time. He assumed that the progeny of single plants would breed true to type. Both these breeders made one initial selection, followed by rapid multiplication of the progeny.

Hallett[3], in 1857, introduced the principle of repeated selection. He bred his plants from the best grain of the best ear of the best plant he could find in his wheat field, and he repeated the process of selection year after year. The strains he produced were a success, and greatly improved the harvests of his generation.

The success of these three breeders was undoubtedly due to the fact that they isolated pure lines which were of superior value to the ordinary varieties.

Vilmorin[4] was one of the first workers to improve wheat by cross-breeding, and described the results of his experiments in hybridizing in 1888.

Rimpau[5] applied the principle of continuous selection to rye, and in 1867 succeeded in evolving Schlandstedt rye, which is now largely grown in France and Germany. Later he worked extensively with wheat, first by mass selection, and subsequently by hybridization of varieties.

Nilsson[6], in Sweden, has been one of the most successful breeders in producing improved varieties of cereals by selection, at the Svalof Experiment Station, established in 1886, in Sweden. The work was based on two discoveries (1) that among farm crops there existed a large number of elementary species which breed true; (2) that superior individuals among these species may be recognized by the possession of certain morphological characters.

W. M. Hays[7], in the United States, introduced the Centgener principle in breeding in 1888. This consists in planting 100 seeds of each

selection in trial plots under conditions which enabled the selections to have equality of environmental conditions. The more promising centgeners were isolated and tested on a large scale. His work resulted in 1892 of two strains whose progeny within ten years were grown on thousands of acres.

William Farrer[8], Australia's pioneer wheat breeder, succeeded in producing a large number of new varieties, many of which were of

Fig. 43.—Second Generation Hybrids.

outstanding merit, and displayed a number of varieties in general cultivation. Much of his work was done prior to the re-discovery of Mendel's Law, by Tschermak, Correns, and De Vries, and though he was not aware of Mendel's experiments, it is clear from a perusal of his paper, read before the Australasian Association for the Advancement of Science in 1898, that he had observed the fundamental principle of segregation of characters in the F_2 generation from crossbreds. His Federation wheat, a short-strawed, spare stooling, prolific variety, specially suited

to the requirements of the Australian climate, has in many parts of the Australian wheat belt almost completely displaced from cultivation varieties of wheat which had been grown for a generation. Besides producing the prolific variety, Federation, he was successful in obtaining, by cross-breeding three high-grade milling wheats, Bobs, Cedar, Comeback, two varieties highly resistant to smut, Florence and Genoa, and a number of other varieties of value to the climatically different districts of New South Wales. His remarkable success as a wheat breeder gave an impetus to wheat breeding in each of the four wheat States of the Commonwealth. Farrer's work has been of immense value to the wheat industry of the Commonwealth. By the creation of Federation wheat alone he has added millions sterling to the income of the wheat-growers. In some districts of Victoria, notably in the Wimmera, this variety has been almost exclusively grown, and it has added several bushels per acre to the yield of this wheat province since its introduction, nearly fifteen years ago. The wheat has a dark bronze ear, with relatively short, upstanding straw, in marked contrast to the tall, leafy varieties that were hitherto exclusively grown.

It may be said that Farrer has changed the colour of the harvest fields from bright golden yellow to dull bronze—the colour of his own Federation wheat. The wheat-growers of Australia have reason to remember with great gratitude the memory of this retiring, painstaking genius, who carried on his researches in their interest on a mere pittance.

In 1900, Mendel's[9] epoch making work was rediscovered by Tschermak[10], Correns and De Vries[11]. The law which Mendel discovered laid the foundation of modern genetics, and provided a scientific basis for plant breeding. Since the rediscovery of Mendel's Law many workers have conducted confirmatory investigations with cereals. Of these the most prominent were Spillman, Biffen, Tschermak, Nilsson-Ehle, and Howard.

Spillman's[12] work was of great interest, because it described experiments carried out on the same lines as Mendel's, though the author at the time was unaware of Mendel's work.

Biffen[13] discovered that susceptibility and immunity to Yellow Rust (*Puccinia glumarum*) behaved as a pair of Mendelian characters. He also worked out the mode of inheritance of a number of botanical characters in wheat.

Tschermak[14] records the results of his own and other investigations relating to the inheritance of morphological characters in wheat. He found that the following pairs of characters behaved as dominant and recessive characters respectively: (*a*) solid stem, hollow stem; (*b*) keeled glumes, rounded glumes; (*c*) beardlessness, beardedness; (*d*) felted glumes, pubescent glumes; (*e*) coloured chaff, white chaff; (*f*) red grain, white or yellow grain; (*g*) flinty grain, floury grain; (*h*) susceptibility to yellow rust, immunity to yellow rust.

Nilsson-Ehle[15] carried out confirmatory investigations with varieties of wheat grown in Sweden. Among the more important results of his work was the determination of ear structure in wheat. His researches showed that the lax character of ear in *Triticum vulgare* is often dependent on two (possibly more) factors (L_1 and L_2) over which the single factor for short ear in *Triticum compactum* is dominant. On

the other hand, crosses between *T. compactum* and *T. vulgare,* by Spillman[16] and, Gaines[17], have shown one main factor difference for compactness. Similar results were obtained by Biffen[18].

Most investigators agree that coloured chaff behaves as a simple dominant to white chaff. The usual segregation in F_2 is 3 : 1 coloured to colourless. On the other hand, Nilsson-Ehle found that certain red-chaffed Swedish wheats gave in F_2 a segregation of 15 red, 1 white. He assumed that red colour in this case was due to two separately inherited red factors, each of which produced by itself a red tint, and when acting together they have a cumulative effect. In a *T. durum* x *T. vulgare* hybrid Love and Craig[19] obtained in F_2 a 15 to 1 ratio for

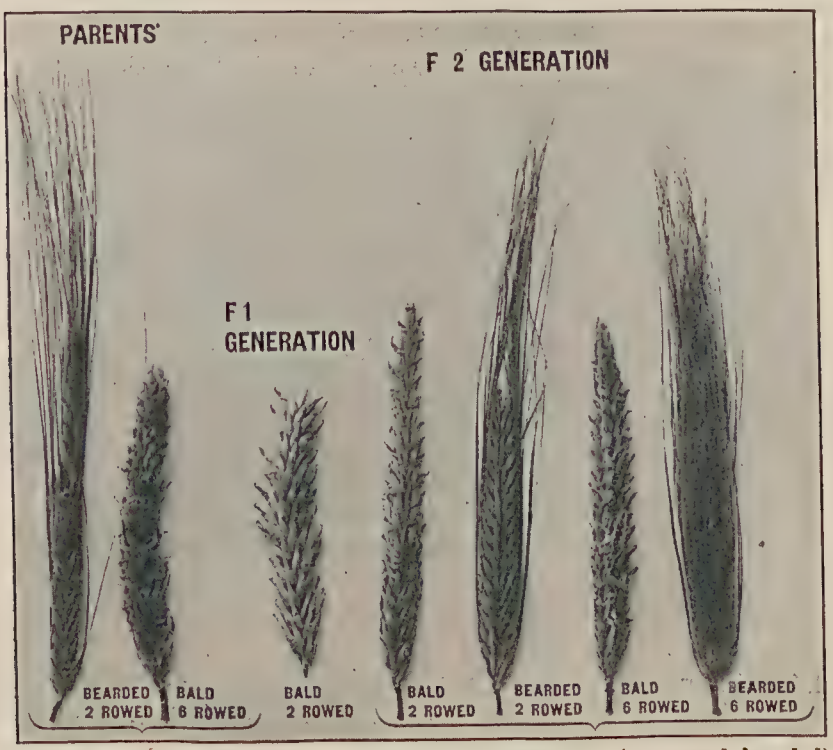


Fig. 44.—Cross-bred Barleys produced by Hybridising Pryor (two-rowed, bearded) and Skinless (six-rowed bald).

brownish-red and colourless chaff. Biffen, Howard[20], Tschermak, Kezer, and Boyck[21] all record simple 3 : 1 ratio for colour in F_2.

Biffen observed complete linkage of grey colour of glumes with hairy chaff. Engledow [22] crossed a black glumed wheat obtained from a turgidum x fife cross with a rough-chaffed, white-glumed variety, Essex. The ratio in F_2 was explained on the basis of repulsion for the black glume colour and those for hairy chaff on the 1 : 3 : 3 : 1 series.

Colour of seed, due to a brownish-red pigment in the testa, has been used to classify varieties. Red is dominant over white, and in F_2 a ratio of 3 red-seeded plants to 1 white seeded is often obtained.

Nilsson-Ehle[23] was the first to report crosses which in F_2 gave 15 to 1 and 63 to 1 ratios of red and white seeded plants.

This is explained by the colour being due to several factors, each, when present, giving red, and when absent, white. These factors are separately inherited, and each when homozygous producing a darker seed than when one colour factor is present.

The hardness of seed is often used to classify varieties. Biffen [24] found that hard and soft seeded crosses segregated in the ratio of 3 to 1 hard seeds to soft seeds.

Hard, translucent endosperm, however, while characteristic of certain varieties, particularly the durum wheats, may be developed by environmental conditions. If wheat ripens rapidly, hard endosperm tends to form, while if the period of maturity is slow the endosperm is well filled with starch cells. A variety with naturally soft endosperm may, when grown in a soil rich in available nitrogen, or under conditions which lead to rapid maturity, develop high nitrogen content, and relatively hard endosperm. High nitrogen content and high starch content in grain appear to be mutually antagonistic.

Much attention has been devoted to a study of inheritance of disease resistance. Biffen found that the inheritance of host reaction to *Puccinia glumarum* is a simple Mendelian character. In F_2, 3 susceptible to 1 immune forms were obtained.

Pole-Evans[25], in South Africa, showed that susceptibility to *Puccinia graminis* was dominant and resistance recessive, as in *P. glumarum*.

Stakman and others[26] have shown the probable reason for conflicting results obtained in studying the inheritance of resistance in *P. graminis*. They have demonstrated that there are a number of distinct biologic forms of rust. These forms can be distinguished only by their specific reaction to pure line wheat varieties. Studies of their constancy indicate that they are not easily modified, i.e., the parasitic reaction of each form is constant. They have isolated no less than 38 distinct biologic forms of rust, *P. graminis*.

This makes the problem of breeding for rust resistance very complicated, because of the existence of so many biologic forms. Waterhouse, of Sydney University, has isolated two distinct biologic forms of rust in Australia. Farrer endeavoured to breed varieties of wheat resistant to bunt, and succeeded in producing two varieties, Florence and Genoa, which possessed a high degree of resistance. His method was to thoroughly impregnate the seed of his new crosses with smut spores, and sow the seed in nursery rows. Selections were made from plants which were quite free from smut.

H. Pye, of Dookie College, has been very successful in producing a number of valuable crossbred wheats highly suited to the soil and climatic conditions of certain areas in the State. Among the most popular of Pye's productions are Warden, a hay wheat, Currawa, and Major, two mid-season to late varieties of high-yielding capacity, and Minister, a variety of high-milling quality. These varieties are widely grown in Victoria. Like Farrer, Pye has used cross-breeding as a means of producing his new varieties.

During recent years there has been an immense accumulation of more or less precise knowledge of the mode of inheritance of the chief characters in wheat, but much work remains to be done. The inheritance of what may be termed the botanical characters of wheat has

been determined, but very little work has been done on the inheritance of quantitative characters.

The morphological characters are of less economic importance than grain-yielding capacity. Like most quantitative characters, grain-yielding capacity is probably a complex of many factors, and its manifestation is so greatly influenced by external or environmental conditions that its mode of inheritance is obscured. It has been shown by the writer*, however, that where special efforts are made to ensure a uniform environment, e.g., in the centgener system of planting, the F_2 progeny of crosses between high and low yielding variants may be obtained which give substantial differences in yield.

While segregation of high and low yielding variants undoubtedly does occur, the determination of the factors which make up the complex mosaic of prolificness has still to be determined.

Fig 45.—First Generation Hybrid (Jonathan × Indian F) showing grass tufts or dwarf forms. Three mature Jonathan plants at head of row, ten dwarf F hybrids, and three Indian F plants at bottom of row.

How Improved Varieties may be Obtained.

There are two general methods by which improved and new varieties may be obtained, namely, by—

1. Selection.
2. Cross-breeding.

We will consider each of these.

It must be borne in mind that in a young country like Australia many varieties of value may possibly be obtained from the older agricultural countries of the world, where wheat is grown under conditions not unlike our own.

Some preliminary acclimatization is usually necessary in these cases.

* A. E. V. Richardson. Production of Wheat for Arid Districts. Bulletin, Institute of Science and Industry, Melbourne.

Methods of Selection.

There are two general methods of selection adopted by plant-breeders—*mass* selection and *individual* selection.

Mass selection consists of the continuous and repeated selection of a number of the best grains, ears, or plants. It is based on Darwin's conception of the origin of species, and it is supposed that by the repeated selection of a number of élite plants each year, the race, as a whole, will be gradually improved.

De Vries denies that any permanent improvement can result from mass selection.

Fruwirth, on the other hand, affirms that mass selection does result in permanent improvement.

The effect of mass selection, as applied to oats, barley, and potatoes, has been strikingly demonstrated by Professor Zavitz at Ontario.* The following table summarizes the results of sixteen years' continuous mass selection on these crops:—

Table XXV.—Average Yield in Four Periods in Bushels per Acre of Oats, Barley, and Potatoes, Showing the Effect of Mass Selection on Self-fertilized and on Vegetatively Produced Crops.

Crops.	1890–93.	1894–97.	1898–1901.	1901–05.
	Bush.	Bush.	Bush.	Bush.
1. Oats—Average for 8 varieties ..	74	79	83	100
2. Barley—Average for 8 varieties	50	54	63	63
3. Potatoes—Average for 8 varieties	120	216	218	249

Mass selection is most effective when the individual plant is made the unit of selection, and not the individual ear or the individual grain, for it frequently happens that large grains and large ears of wheat are found on relatively poor plants.

Mass selection thus practised tends towards improvement of the type by propagating from the best plants and excluding all the rest. It may, of course, happen that some of the selections thus made are superior because they have been grown under favorable environment. They may, for example, have received an extra amount of superphosphate through the irregular working of the drill, or they may have been favoured with more space to develop than the majority of plants in the crop. However, the repeated and rigorous selection of the best plants would gradually confine the choice to what might be termed the permanently superior plants, and the general character of the crop would gradually improve in the desired direction.

Mass selection has been practised with success at the German experiment stations, and by such breeders as Rimpau, Drechsler, and Mokry. There are several different ways in which this method of selection may be applied. Whatever method is adopted must obviously involve as little labour as possible, and take up a minimum of time. To be completely effective, the selection must be continuous and uninterrupted.

* Report, Ontario Agricultural College, Canada, 1905.

Mass selection has been practised on the varieties distributed from seed from the Victorian State Farms since 1913. The method used has been as follows:—

Each year 4 to 5 lb. of graded seed are obtained from the best developed heads of robust, well developed, prolific plants, and sown in a "selection" plot of one-twentieth of an acre in area. Each year the process of selection is repeated, and the selected seed sown on selection plots. The balance of the selection plot is harvested each year and sown on a half-acre variety plot. The produce of the variety plot is sown each year on the "bulk plot" of 10 acres which furnishes the seed for sowing the large paddocks of the farm. The plants chosen for the "selection plots" each year may be superior to the remainder of the plants for two reasons—(1) favorable environment, or (2) because they are genetically superior types. The chosen plants may have had more room for development than their neighbours, or they may be growing on a small patch of high fertility. In this case selection will not be effective. They may, however, be really superior plants, because of some genetic characteristic, in which case their progeny will give a superior strain.

On the whole, while this method of selection may not result in much improvement in the variety, it certainly should at least maintain the yielding capacity of the variety.

Individual Selection.

When the individual plant or ear is made the starting point, we have what is known as individual selection.

In this case the selection commences with a number of superior plants of a given variety, and the seeds from each plant or ear are planted in separate rows, and kept under continual observation. This enables a strict comparison to be made of the progeny of each selection, so that in a few years the best strain in the original selections may be determined and multiplied for future use.

Nilsson, at Svalöf, after subjecting the older methods of mass selection to a critical examination, decided to adopt the method of single-plant selection used by Shirreff and Le Couteur, and has achieved a considerable amount of success. The method of procedure has already been described. As a principle, it is based on De Vries' conception of the origin of species, and it assumes that repeated selection is unnecessary.

Attempts have been made to correlate yielding capacity in cereals with certain botanical characteristics, but on the whole it is difficult to establish a consistent correlation between such characters and yield.

Some correlations are, however, of value in selection. Thus, if we are aiming at the production of an early-maturing variety—a great desideratum in a semi-arid region with a short growing season—reliable results may often be obtained by classifying plants according to awn emergence or appearance of the ear in wheat and oats.

Over 200 varieties of wheat, oats, and barley were studied at Longerenong from 1913 to 1918 in this way, and in favorable years, e.g., 1915 and 1916, a high correlation was found to exist between the date of

heading and the date of maturity of the variety. In unfavorable years, e.g., 1914 to 1918, the date of heading was found to be a far more reliable indication of the inherited differences between early maturing and late strains than the actual date of maturity, for in dry years the ripening of all varieties is greatly accelerated.

The migration ratio, i.e., the relative proportion of grain to total straw, is a very useful factor in selection of varieties for semi-arid regions, for varieties with a high proportion of grain to straw are especially suited to mature grain in these regions.

No one character is, however, closely enough associated with yield to be of selection value in isolating high-yielding strains, for yield is the final result of many growth characters. A strain which excels in stooling capacity, drought-resistance, disease-resistance, size of head and numbers of seeds per head, will naturally be a high yielder. Hence, instead of basing the selection upon botanical or morphological characters, as was formerly the case, the principle now generally adopted is to select a large number of individuals on account of special excellence, and test these in separate nursery rows over a period of years, retaining only those which, on the basis of actual yield compared with standard types, give outstanding results.

The limits of selection must, however, always be borne in mind. Its function is merely isolation of the best strains or types, and when once this has been brought about, it is doubtful whether further selection can improve the strain unless some germinal change brings about a new and striking variation (mutation).

Crossbreeding, however, offers a certain means of improving wheat varieties, for by this means the desirable characters of several strains may be combined into one new variety. With Mendel's Law of Inheritance, as a guide, the pure breeding new forms may be isolated with absolute certainty.

How the Crossing is Done.

The ear of wheat is known as a spike, and consists of a flattened stem or rachis bearing alternately a number of spikelets. Each spikelet consists of several flowers, from each of which a seed may develop. The flower itself consists of two parts—(*a*) the protective parts, consisting of glumes and palae; (*b*) the essential parts—stamens and pistil, i.e., male and female organs.

We are concerned here especially with the essential organs. The stamens are three in number, and represent the male organs. Each stamen consists of a slender stalk—the filament, bearing at its summit the anther or pollen sacs, which in the case of the wheat plant consists of four longitudinal chambers containing large numbers of minute pollen grains (sperm cells).

The female portion of the flower—the pistil—consists of the ovary with a minute ovule (or egg cell). The upper part of the ovary bifurcates and forms two long, slender, feathery structures—the styles.

The pollen grain falls on the stigma of the flower and "germinates" sending a slender prolongation through the style until it reaches the ovule when fusion and fertilization takes place.

In the case of the wheat plant the flowers are normally self-fertilized. Natural cross fertilization is very rare. Moreover the flowers are hermaphrodite, i.e., male and female elements are borne on the same flower. The wheat plant is said to be in "flower" when the anthers begin to extrude from the glumes. With wheat, however, fertilization takes place before "flowering." In order to cross one variety with another it is necessary that the pollen of one variety should be dusted on the ripe stigma or female part of the second variety. The plant from which the pollen is taken is generally described as the male parent, whilst the plant on which the crossing is done is referred to as the female parent. I find the following method gives satisfaction. A well developed "ear" of the "female parent" is chosen and prepared in the following manner:—

> The basal spikelets amounting to approximately one-third of the ear are stripped off, and the top third of the head removed with a pair of scissors. About four or five spikelets are thus left on each side of the centre of the ear. These spikelets invariably contain three to five flowers. All flowers save the outside pair are removed with a pair of forceps. Thus the ear is reduced to from twelve to twenty flowers. It is now necessary to "castrate" the flowers by removing the three anthers from each. The point of the forceps is gently inserted between the upper margins of the inner and outer pales, and, by releasing the pressure on the forceps the flower is gently forced open, exposing the three anthers and the feathery stigma. With a little practice these anthers may be removed unbroken with one stroke of the forceps. It is, of course, necessary to prepare the ear in this fashion before any of the anthers have shed their pollen grains. The best stage at which to carry out the operation is when the anthers are just approaching maturity and turning yellow in colour. Having "castrated" the whole of the flowers by the removal of all traces of the anthers, the ears may be wrapped in cotton wool until the stigmas of the flower become "receptive" or ready to receive the pollen. The cotton wool may then be removed, and ripe anthers of the particular variety desired as the male parent should then be secured. The anthers should be quite "ripe" i.e., bright yellow in colour, and just ready to burst. The anthers are seized with a fine pair of forceps, broken in halves, and the contents gently shaken or dusted over the feathery style of the female ear. Each flower is treated in succession in this way, and frequently, when the pollen is not in good condition, some of the anthers may be broken and left inside the protective glumes of the flower.
>
> Instead of "castrating" and pollinating the flowers on different days, it is generally more convenient to remove the anthers and cross-pollinate the stigmas at the one operation. Is is necessary in such cases that the stigma and anthers should be fairly "ripe," and care should be taken that self-fertilization does not occur. Any flowers in which the anthers have already liberated pollen should be suppressed.

After the crossing is finished the ear is wrapped up in cotton wool, or surrounded with a light paraffined paper bag to prevent the possible entry of foreign pollen. The ear is then labelled with the names of the male and female parents, date of cross, &c., and supported by a stake. A fortnight later the protective covering may be removed, and the ear allowed to ripen.

Method of Producing New Cross-breds.

The cross-fertilized seed is sown the next season in single rows with the pollen parent and the ovule parent at either end of the row. By this means a comparison may be made throughout the period of growth between the parent plants and the crossbred progeny. The crossbred seeds give uniform progeny the first season, with the dominant characters of the parent showing up. At the end of the season the F_1 plants are

Fig. 46.—Testing New Cross-bred Wheats for Yielding Capacity.

separately harvested and sown the next year in single rows, each plant being given a separate row. During the second generation the rows are very varied in appearance, due to segregation and recombination of the various characters conveyed to the cross from the two parents.

All the combinations of characters which would be expected from Mendel's Law are now presented to the wheat-breeder, and his aim is to select those combinations which give promise of producing new and improved varieties. It is just at this stage that he experiences his greatest difficulty. There will be many types apparently similar in character, but though in appearance alike they may be different in gametic constitution. Most of the plants, if sown in separate rows, will continue to segregate. A few, very few, but always a definite proportion of the whole, will breed absolutely true to type.

It is at this stage that the breeder needs to exercise great patience. For example, with a cross involving, say, four dominant characters, only one plant in every 81 showing these dominant characters will breed true. Of the plants showing any three or four dominant characters only one

in every 27 will breed true, &c. It is, therefore, necessary that the selections made from plants showing dominant characters should be sown in separate rows for another generation (F_3) in order to determine whether they are pure breeding (homozygous) forms or impure (heterozygous) types.

Theoretically, it should be possible to produce pure homozygous forms of any given gametic constitution in the third generation. In practice this is not always possible. Forms homozygous for ear characters, e.g., bearded and bald, coloured or white chaff, lax or dense ears, pubescent or glabrous chaff, red or white grain, keeled or rounded glumes, flinty or floury grain, may be fixed readily enough; but the forms homozygous for these ear characters may vary greatly in habit, period of maturity, susceptibility to disease, tillering capacity, hollowness or solidity of straw, tallness or dwarfness of stem, and most of all in yielding capacity. Hence, even though forms apparently homozygous for ear characters may be obtained in F_3, an inspection of such plants will usually reveal considerable variations in what might be termed the agricultural characters, which largely determine the practical value of the new crossbred.

If the rows showing uniformity in ear characters in F_3 are subjected to further selection on the basis of earliness or lateness of maturity, hollow or solid straw, tall or dwarf habit, apparent yielding capacity, &c., forms homozygous for ear characters and agricultural characters may be obtained in the fourth generation, provided the progeny of each plant is again sown separately, and provided also a sufficient number of selections for each character be made.

We have, therefore, adopted a working basis for the creation of new crossbred wheats at the State Research Farm, the system being as follows:—

(1) Plant in the first generation the seeds of the crossbred plants in single rows, with the parent plants at either end of the row for purposes of comparison.

(2) Sow the seeds of each F_1 plant the second season in separate rows and observe the mode of segregation.

(3) A number of single plants of each phenotype are sown in separate rows in F_3, the number of rows depending on the number of factors in the parent forms. From these single-row cultures all those uniform in ear characters are retained for further selection. Heterozyous forms are rejected.

(4) If these plant-row cultures are uniform in ear characters, and show no variation with respect to period of maturity, habit of growth, character of straw, or apparent yielding capacity, the crossbreds are regarded as fixed. If, however, the plant-row cultures show variations in these latter characters, the F_2 progeny are subjected to further single-plant selection and the single-row cultures are continued in F_4, and if necessary in F_5.

(5) When crossbreds homozygous in both ear and agricultural characters are obtained, they are then subjected to one final test-yielding capacity compared with standard varieties. The testing of the new crossbreds is effected by sowing each in rows 5 to 10 chains long, side by side with standard varieties. Federation is the variety used for this

purpose. It has hitherto been the most consistent yielding wheat grown in the Victorian wheat belt.

For the past five years some 200 fixed crossbred wheats have been tested in long rows with check plots of Federation every tenth row, and the best 40 of these have been sown the following year in selection plots of 1-20th of an acre, and from these again the best 20 are selected to compete in ¼-acre variety plots.

In short, the principle we have followed is to first fix the new crossbred with regard to its botanical and agricultural characters, and then subject it to rigorous testing over a series of years to test its yielding capacity.

The first two crossbreds fixed and tested in this manner were Gallipoli and Graham. The yields of these two varieties at Longerenong College since 1918, and the yields of Federation and Yandilla King, are as follow:—

	Federation, bushels.	Yandilla King, bushels.	New Crossbred Graham, bushels.	New Cross, Gallipoli, bushels.
1918 ..	41.4 ..	34.7 ..	34.6 ..	45.8
1919 ..	27.5 ..	22.5 ..	26.1 ..	32.3
1920 ..	57.6 ..	56.0 ..	60.0 ..	69.0
1921 ..	40.3 ..	40.6 ..	38.1 ..	39.3
1922 ..	38.0 ..	37.3 ..	44.6 ..	44.6

The yields show variations, but it is evident that over a series of years the crossbred Gallipoli gives considerable promise.

These results show definitely that material improvement in grain-yielding capacity may be brought about by cross-breeding.

Many morphological characters of the wheat plant, e.g., colour of chaff and grain, presence or absence of awns, laxity or density of ear, hairiness or smoothness of chaff, &c., are dependent on single Mendelian factors which are transmitted from parent to offspring independently of each other, and the plant-breeder is able to remove or add these separate hereditary units at will, or associate any combination of them into one variety. These morphological characters are of less economic importance than grain-yielding capacity. Like most quantitative characters, grain-yielding capacity is probably a complex of many factors, and its manifestation is so greatly influenced by external or environmental conditions that its mode of inheritance is obscured.

The yielding capacity of a given variety is the resultant of genetic characters as well as environmental conditions. The type of wheat raised must be well suited to its environment to give substantial returns. As the environment varies from region to region, the problem of producing prolific wheats is one that must necessarily be more or less local in character. For the drier regions a wheat must possess earliness of maturity and high migration ratio.

The writer has shown* that October is the critical period for the wheat crop in Australia. October is invariably associated with high temperatures, low humidity, and hot northerly winds. At this period transpiration rises to a maximum for winter-grown cereals, and supplies of soil moisture ars approaching exhaustion.

* A. E. V. Richardson. Water requirements of farm crops, Bulletin, Department of Agriculture, Victoria, p. 90.

Varieties of wheat which are well on to maturity before these hot northerly winds set in are likely to have a low water requirement and to suffer less from shortage of soil moisture than late-maturing varieties, the ripening period of which is coincident with intense evaporation.

Moreover, while wheat varieties do not differ very materially in regard to their water requirements for dry matter, they do show wide differences in the transpiration ratio for grain, owing to the wide variation in the migration ratio: Varieties with a high migration ratio were found to have a lower water requirement for grain, and could use the scanty supplies of soil moisture for grain production more economically than those with a low migration ratio. Hence, early-maturing varieties with a high proportion of grain to straw are likely to be the most prolific varieties for the semi-arid regions of Australia.

Conclusion.

Whatever methods are used for the improvement of wheat, it is essential that the wheat-breeder should have a clear conception of the ideal towards which his efforts are to be directed. His aim will vary in different countries; his methods will be alike in all. The aim will be to combine into one variety those desirable unit characters which will make a wheat adapted to the environment in which it is grown. The wheat which is best suited to the English farmer may be useless in Australia, India, or southern Europe, for in cool, temperate climates the selection of forms with a naturally long-growing period may be necessary to ensure heavy grain production. Such slow-maturing wheats would be of little value in Australia, and would be easily surpassed in grain production by early-maturing, short-lived wheats. On the other hand, the early-maturing Australian varieties would be of little value in England.

The methods available to the breeder are selection and cross-breeding. The aim and action of selection is to detect the desired heritable variants among commercial varieties and through them isolate a race with the desired characters. When this is accomplished, selection can do nothing more until nature produces another desirable variation. Selection is therefore not creative in its action. It merely isolates desirable variations which have occurred through natural causes, of which little is known. If the practical results of selection appear to be part of a continuous process, it is because of the imperfect methods at hand to isolate the desirable variations.

Cross-breeding, on the other hand, enables the plant-breeder to combine into one variety the unit characters of two or more types and thus create a new combination or variety. It is the most valuable instrument the breeder possesses for the creation of new types adapted to specific environments.

To make real progress in wheat-breeding it is necessary that the wheat-breeder should not only be familiar with the morphological and agricultural characters of the wheat plant and to know the manner in which these various characters are inherited, but that he should also have a clear conception of the specific characters which should be combined into a new variety to make it suited to the local climatic requirements.

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FERTILIZERS AND THE FERTILIZER INDUSTRY.

By P. Rankin Scott, Chemist for Agriculture, and Will C. Robertson, Supervising Analyst.

The fertilizer industry in Victoria during the past 20 years has progressed to such an extent that the figures of production are astonishing to most people. It is not more than 25 years since the country storekeeper would with great hesitation direct his customer's attention to a bag of artificial fertilizer displayed in the front of his premises, and solicit an order. To-day the storage has been increased to enable him to carry stocks of at least half a dozen different kinds of fertilizers, and his trade, which in 1898 or thereabouts was counted in bags, has grown into a separate department, where hundreds of tons are handled annually.

Not the least important amongst the multifarious duties of the Department of Agriculture is the administration of the Artificial Fertilizers Act, with its rigid inspection of the many factories manufacturing the various forms of fertilizers, the sampling of consignments in transit and held in stock throughout the country, and the analyses of samples of fertilizers submitted by manufacturers or dealers, or withdrawn by the inspecting officer under the provisions of the Act from the parcels of fertilizers exposed for sale in the country districts.

It should perhaps be stated that in the preparation of this series of articles dealing with fertilizers and the fertilizer industry, the order of the different fertilizers is a matter of departmental convenience, and bears no relation whatever to their relative importance.

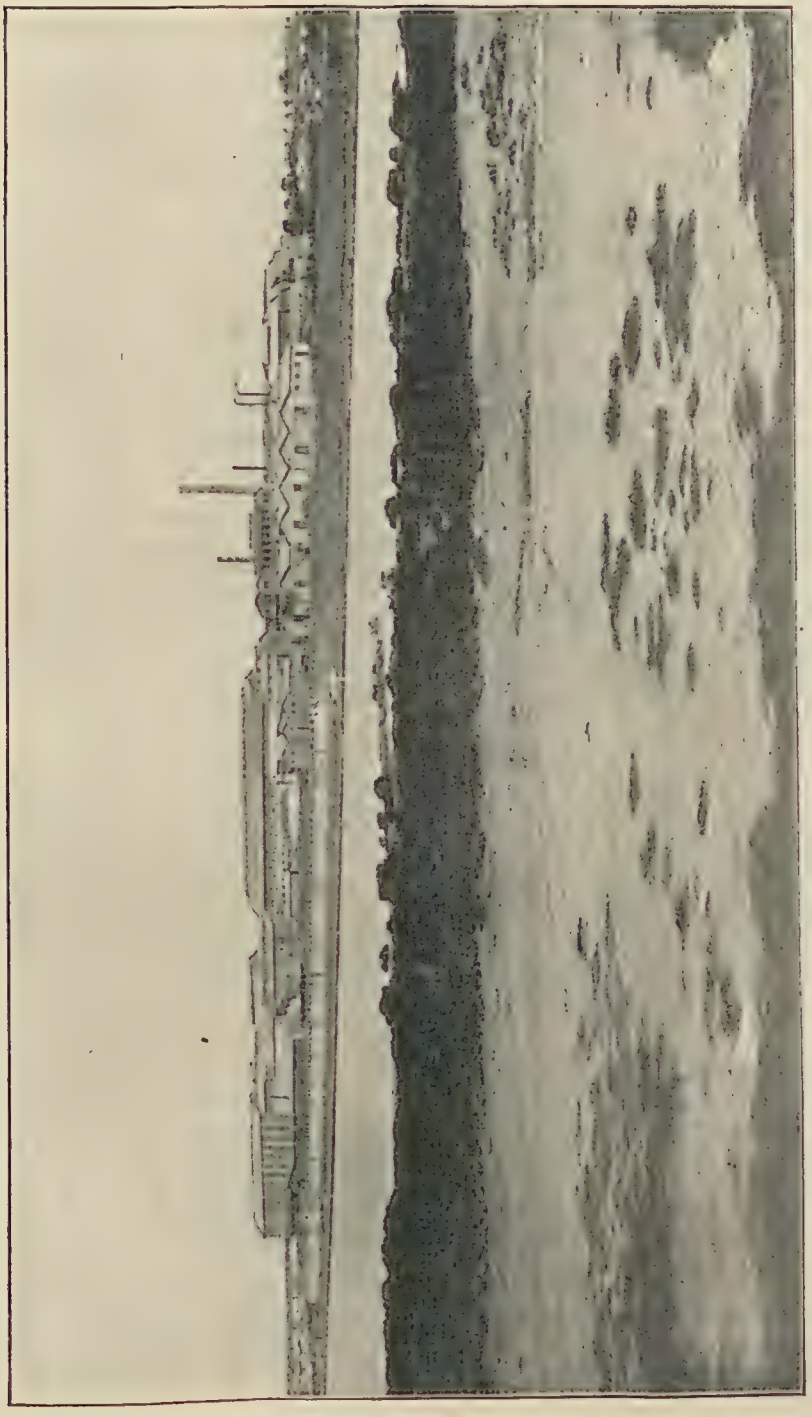
Animal Fertilizers.

The various freezing works established in city and country centres produce very useful fertilizers in the form of "bone and blood," and "dried blood," or "blood manure." These are manufactured as a by-product, but there are installed in some places fertilizer plants to treat abattoir refuse and the like, and, after the extraction of the tallow, to manufacture animal fertilizers similar in character and composition to the fertilizers produced by the freezing companies.

The capital required for the installation of modern freezing works of average size indubitably runs into six figures. The initial perpetual capital requisite for the portion of the works which manufactures fertilizers approximates £10 per ton of the animal fertilizer output, tallow being taken as a by-product. This heavy capital expenditure is essential, for nothing is wasted, the only loss being a portion of the moisture contained in the bodies of the purchased animals. The machinery and plant required for the various operations cost a great deal.

The products of the works are—(*a*) frozen meat or mutton, (*b*) tallow, (*c*) fertilizers, (*d*) sausage casings, (*e*) hides and skins.

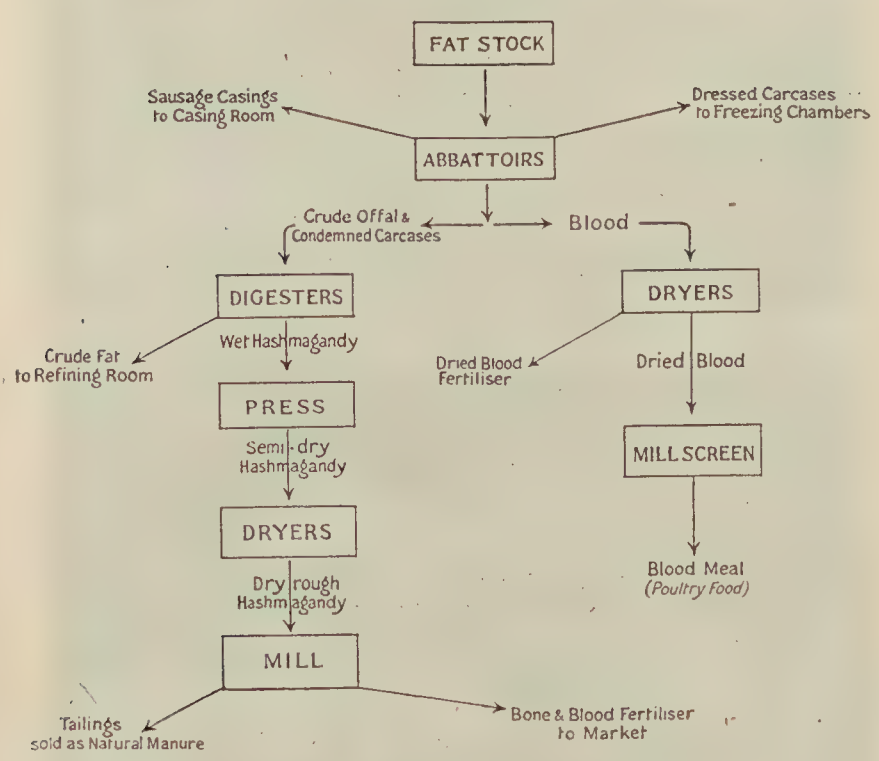
The statement that animal fertilizers produced as by-products cost nothing to make, and provide clear profit, is not exactly correct. One is safe in saying that, at the present moment, the price per ton of the various animal fertilizers on the market in Victoria is very reasonable, and compares more than favorably with similar commodities listed abroad.



Freezing Works, Geelong.

The output of the freezing works will vary with the year and the market for frozen meat and mutton abroad. Instances may be quoted where the price of frozen meat abroad and the price on the hoof in Australia did not allow a sufficient margin for profit, and the output of animal fertilizers suffered accordingly. On the average, approximately 12,000 tons of bone and blood and dried blood are produced annually by the freezing works and abattoirs or factories associated therewith in Victoria.

FREEZING WORKS
FLOW SHEET



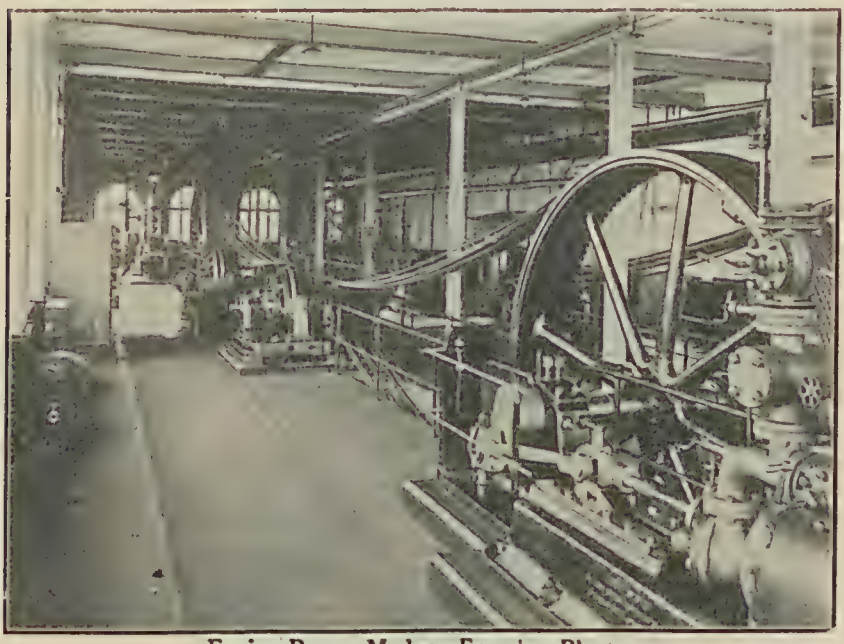
"Bone and Blood" Manufacture.

The main fertilizer produced from abattoirs refuse is termed "bone and blood." The manufacture, briefly, consists of three operations, viz., (*a*) steam digesting, (*b*) drying, (*c*) disintegration.

The following flow sheet will illustrate the various stages in freezing works routine:—

The animals are slaughtered, and the dressed carcasses are dispatched to the freezing chambers. The offal, consisting of heads, horns, stomach and contents, intermixed with a small amount of blood, together with all condemned carcasses, are dispatched to the "digester" room, where

the whole is tipped into the digesters, which are really vertical boilers without tubes. Two doors, one at the top, the other at the bottom of



Engine Room, Modern Freezing Plant.

Tallow Room showing Casks of Tallow.

the digester, permit filling and discharging. Here the raw material is subjected to a process of steaming under pressure, with the twofold

object of "sweating" the tallow out of the refuse, and at the same time softening the bones, thereby permitting easy disintegration in the subsequent operations.

Regulations under the Health Act in the case of fertilizers intended for export to another State require the steaming to take place under pressures ranging from 30 to 40 lb. per square inch for five hours. For local trade the manufacturer pleases himself as to how long and under what pressure the steaming process is conducted.

When the raw material is judged to be "cooked," steam is turned off, and the fat (tallow), being lighter than water, is floated off and conveyed to the tallow room for refining prior to being run into casks and sold. The preparation and refining of tallow is an art in itself, and carries with it many trade secrets, the outcome of years of experi-

Battery of Digesters showing Presses.

ence in the trade. Australian brands of tallow are much sought after abroad, and a large proportion of the annual output is periodically exported.

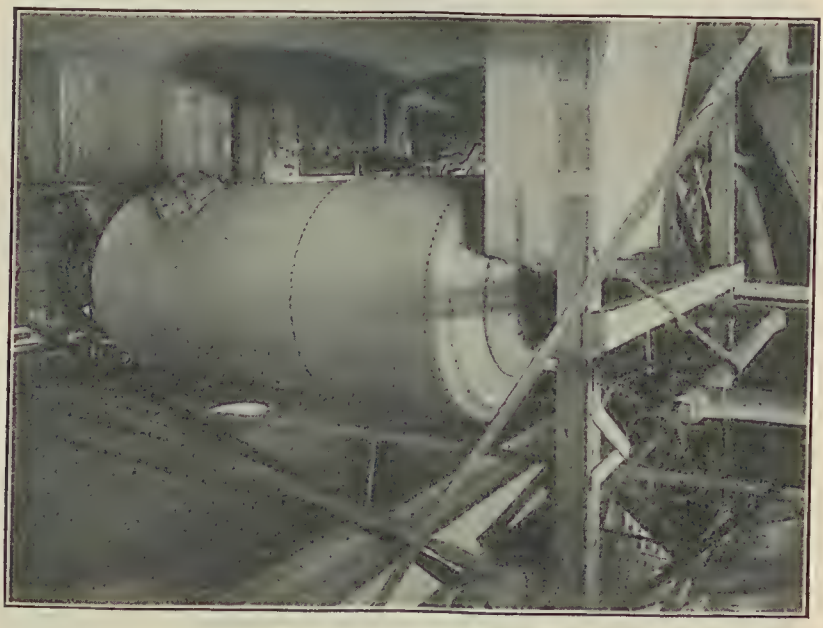
The residue remaining in the digester is termed "hashmagandy." It is treated by turning on the tap in the bottom of the digester, and the "soup" is run off. No attempt is made to recover the soluble albumoid matter in the "soup." No doubt some economical system of recovery by precipitation would be installed but for the fact of the obnoxious smell, and the necessity of avoiding complaints by discharging into the sewer forthwith.

The "hashmagandy" is next discharged into presses, where the excess moisture is pressed out, after which the semi-dry pressed material is conveyed to the "dryer." A "dryer" consists of a large horizontal revolving vacuum cylinder, steam-jacketed and fitted internally with

cleverly arranged cleats, which, as the " dryer " slowly revolves, continually lift and drop the moist " hashmagandy " through the hot vacuum. As the moisture is driven off in the dryer, the vacuum removes it, and finally after some hours the hot, dry " hashmagandy " is discharged.

The operation of discharging is brought about by stopping the revolving dryer, removing the two doors, which are fitted to either end, but on opposite sides of the dryer, and then re-starting the machinery. As the dryer slowly revolves, the fertilizer automatically falls in two heaps on the floor underneath.

The number of digesters and dryers in different freezing works varies. In some of the large works as many as six or eight digesters and four or six dryers may be seen in commission. The small fertilizer works, however, have two digesters and one dryer.



Modern Revolving Dryer.

The fertilizer on being discharged from the dryer is in a rough, crude condition, and is immediately conveyed to the crushing mill. This usually consists of two sets of "beater" wheels, which revolve one within the other at very high speed in an enclosed box. The soft bones are readily disintegrated by the smashing action of the " beaters," and pass through a revolving trommel screen, the coarser particles being returned for re-grinding if necessary. In the latest type of mill the " beater " wheels are set as rolls—a distinct improvement.

In some of the more modern plants in the larger freezing works, the mixture of fine and coarse material from the dryer passes through the trommel screen prior to its going to the mill, and the coarse particles only go through the mill, thereby avoiding the " dead load " of already pulverized fertilizer. From the trommel screen the fine material is con-

ducted down a shoot at the side of the mill, and then underneath; there it meets the discharge from the mill, and is automatically mixed and

Mill and Bagging Machine.

Bone and Blood ready for Market.

elevated to the bagging machine, where it is bagged, weighed, sewn, branded, labelled, and marketed.

There is an overtail from the mill screen which is termed "tailings." This consists mainly of wool, hair, and hard pieces of bone. It is not possible to economically re-treat this material, and it is sold ex-works, and is eminently suited for market gardens.

The finished article which is called bone and blood, is a fine, dry, dark powder, more or less "speckled" with white particles of bone. It contains from 50 to 60 per cent. of organic matter, which, when applied to the soil, produces humus The nitrogen content varies with the raw material passing through the works.

Heavy beasts yield a different crude offal from lighter animals, with a corresponding difference in the analysis of the finished article. For example, bone and blood fertilizer produced from the condemned carcasses and offal of sheep intermixed with condemned carcasses of rabbits would show a different analysis from the bone and blood fertilizer produced from the condemned carcasses and offal of sheep alone.

Ballarat Freezing Works.

The greater the quantity of bone passing through the works the higher the percentage of phosphoric acid in the finished article. Likewise, it follows that when blood and meat are predominant in the crude refuse, the resultant fertilizer will show a high content of nitrogen.

Bone and blood fertilizers from different factories show a variation from 5 to 7½ per cent. of nitrogen, and 15 to 9 per cent. of phosphoric acid. This means that one may purchase a pure, unadulterated bone and blood fertilizer which may show an analysis of 5-15 (5 per cent. of nitrogen and 15 per cent. of phosphoric acid), or 7.5-9 (7.5 per cent. of nitrogen, and 9 per cent. of phosphoric acid), or any grade between these figures. The usual grade produced, however, by the freezing works gives the following analysis:—

Nitrogen (as bone, flesh, and blood)	6%
Phosphoric acid citrate, soluble	5%
Phosphoric acid citrate, insoluble	7%
Phosphoric acid, total	12%

Bone and blood has a particularly good mechanical condition, which permits intimate contact and exposes a large surface area to the solvent action of soil water and the decomposing influence of soil bacteria upon the fertilizing constituents—nitrogen and phosphoric acid—resulting in the rate of availability being accelerated.

One of the keenest objectives in fertilizer factories manufacturing animal fertilizers is the recovery of tallow. The percentage recovery is good, yet some of the oil or fat remains in the fertilizer, and this has the disadvantage of acting as a waterproof coating, and thereby retarding decomposition.

A satisfactory feature of the output of the freezing works is the absence of adulteration. No sand, marl, gypsum, or other foreign matter is used there, consequently the whole body of the fertilizer is available for soil improvement and plant nutrition.

Bone and blood being a fertilizer within the meaning of the Fertilizers Act, it is required that it be registered as a fertilizer at the office of the Director for Agriculture, and an invoice certificate or guarantee must be tendered to purchasers.

The bags containing the fertilizer are required to be branded with the registered brand, and each and every bag must have a label affixed, complying with the regulations and guaranteeing the contents. The following is an illustration of the correct label used for labelling "bone and blood":—

MANUFACTURED IN VICTORIA

SMITH & CO. Pty. Ltd.

DRILL BRAND BONE AND BLOOD

Contains

NITROGEN as Bone, Flesh, and Blood	-	6%
PHOSPHORIC ACID—		
Citrate Soluble - -		5%
Citrate Insoluble - -		7%
Total	-	12%

515 GEORGE STREET, MELBOURNE

NET WEIGHT, 112 lb.

(To be continued.)

POTASH FROM SUNFLOWERS.

In spite of crop failures and famine at home, Russia has within the past two years been exporting considerable quantities of potash. The Russian product is extracted from the rich soils of south-eastern Russia by burning the stalks of sunflowers, which are extensively grown there. Last year more than 500,000 acres were devoted to this purpose, the yield of potash being from 160 to 190 pounds to the acre. The Russian potash is purer than the German, which is mined from the earth, and, before the war, was successfully sold in Germany in competition with the local product.—*The American Fertilizer.*

COTTON-GROWING EXPERIMENTS.

By C. J. R. Johnston, Field Officer.

Murray Valley farmers are keen to know whether there is any likelihood of cotton ever becoming a staple crop on their lands under wheat-growing or even irrigated conditions. Some light has been thrown on this question by the results of a series of experiments conducted by the Department of Agriculture at Wahgunyah.

The experiments were carried out at the Wahgunyah Nursery. Planting was commenced on 8th October, 1923, and completed on 31st October. The plots were nicely placed on a bank of sandy loam on the Murray River, from which water for irrigation was drawn.

Initial preparation of the soil consisted of two successive ploughings and cultivatings, some scoop work being done between the first and second ploughings to facilitate irrigation. As the soil was infested with couch grass much springtyne harrowing and cultivating was given to drag as much of the grass as possible to the surface, where it was heaped and burnt.

The 31 plots comprising the tests were divided into five sets of inquiries or sections as follow:—1. Time of seeding. 2. Watering: number of irrigations and time of application. 3. Varieties best suited to locality. 4. Manurial: most profitable kinds and quantities to apply. 5. Spacing and Thinning tests.

Treatment and Planting of Seed.

In all plots with the exception of the varieties section imported seed of Durango variety was sown. To prevent the seed from hanging together it was treated before sowing with strong sulphuric acid to remove the fuzz, or short fibre adhering to the seed coat. This treatment makes the seed smooth and clean, and does not adversely affect it in any way—if anything it is thought to assist germination.

In all plots a distance of 3 ft. 6 in. was allowed between the rows, and the seed was dropped in clumps of six placed 1 foot apart (No. 5 section excepted). The soil, though dry on top, was thoroughly moist at 2½ inches, at which depth the seed was placed. The drills, after addition of superphosphate, were covered in with a hand-hoe, and were tramped to firm the soil around the seed and encourage capillary action; they were then lightly raked to leave the surface loose.

Time of Seeding Test.

Planting commenced on 8th October with the early sown plot of "Time of Seeding" section. Gutters were opened 2½ inches deep, and superphosphate at the rate of 3 cwt. per acre applied in drills with the seed. One hundred and fifty points of rain accompanied by a few very cold days followed some days after planting. As a result of this germination was slow, some seedlings showing through in 15 days, but the bulk of the plot required from 16 to 25 days.

The mid-season planting (normal seeding time), Plot No. 8, was sown eleven days after early-sown plot, i.e., 19th October. Favorable conditions prevailed at planting, and germination was consequently good.

The late-sown plot No. 9 was seeded on 31st October, by which date, the weather being warm and windy, the surface soil had become rather

dry, so that germination was not as good as early and mid-season sowings. Comments on the germination of Time of Seeding Section may be summarized thus:—The germination of the early-sown plot was slow and percentage only fair, whilst that of the late sowing was poor. Mid-season sowing proved to be very much better in relation to percentage germination and time taken to show through.

All other sections were sown between the 18th and 25th October, and it can be said at this point that germination was markedly better in those plots sown during the late mid-season period, from 21st to 25th October, some seedlings showing through in five days from the time of planting of seed. Although the optimum period cannot be absolutely defined, because governed by locality and incidence of spring rains, it can be seen that such period is very short when compared with winter crops.

It was noticed that seedlings had difficulty in pushing their seed-leaves through where a crust had formed on the surface, although the truth of the old adage was illustrated where several seedlings in a clump germinating together would force the crust asunder. Herein lies the value of heavy seeding in tenacious and cementy soils.

Spacing and Thinning Tests.

When 4 inches high the plants were thinned out in one-third of each plot to one plant per hill, and in the next one-third section to two plants per hill. The remaining one-third was thinned later when plants had grown to 9 inches in height, to two per hill. In this test indications were that the best results may be obtained from two plants per hill thinned when 4 to 5 inches in height.

Watering Tests.

This group of six plots was planned to show what time would be the best to apply irrigation water with a view to ripening the greatest weight of seed cotton per acre in a short growing season.

Table showing Time and Frequency of Irrigation of Various Plots.

Plot No.	No. of Waterings.	Time of Watering.
1	Nil	
2	One	One month after planting.
3	One	Two months after planting.
4	Two	The first in November, the second in February.
5	Three	The first in November, the second in February, and the third on the 13th March.
6	Two	One in November and another in March.

Owing to the exceptionally cool and wet summer only two irrigations were necessary in these as in other sections, the first a very light application being given one month after planting. Following this 57 points of rain fell which, with rising temperatures generally, and a few really hot days, promoted good growth in all plots. On 3rd December 40 points of rain fell, followed by hot humid weather, and notes entered on 6th December comment on the remarkable headway made by all sections in this short period.

At this stage a slight difference was noticeable in the unwatered plot, new growth on the tips of the main stems, but particularly of branches, being less vigorous than that of other plots.

Good growth in all sections was maintained up to 22nd December, after which date cold weather with heavy cold rains obtained. The month of January showed little improvement in temperatures over December, with the result that the flowering of all plots was somewhat belated. The middle part of January, however, became hotter, and flowering, which commenced on 16th January in the manurial section, became general from the 25th onward.

On the 4th February the flowering of the unwatered plot was not noticeably different from that of other plots, although the plants were smaller and showed generally fewer buds and less foliage and branch growth.

During a warm spell Plot 5 was given a third watering on 13th March, which produced tremendous lateral growth, the plants becoming very much crowded in the rows, and branches locking across the inter-row space.

From a general survey of all sections and close observation of individual plants, it would appear that a very moderate supply of moisture is necessary up to the commencement of flowering, when, if a fair number of early bolls are set, the vegetative growth is not so vigorous, whereas if only a few early buds form on the plant it continues to grow, if watered, and forms numerous later buds.

Very strong growth was made in all sections during March, and the plants flowered and set bolls freely, but the very dense foliage of many plots proved towards the end of the season to be detrimental to ripening of the bolls on the lower portion of the plants. The unwatered plot contrasted in this respect with the others, the plants there being very much smaller with little lateral growth, slightly smaller bolls, and a lighter showing of later squares or buds.

During April very unfavorable conditions for ripening were recorded. Heavy rains and cold winds reduced temperatures earlier than in the average autumn, as a glance at the chart on page 691 will show.

The first ripe boll appeared on 2nd April in the Spacing Test section, Plot No. 30, in which the hills were spaced at 12 inches, and thinned to two plants per hill.

May commenced bright and fine, with a few frosts which turned the edges of the topmost leaves, but did not affect the bolls. By the middle of the month plots showing the greatest number of normally matured and opened bolls were Nos. 1 and 11, the former having had no irrigation water, and the latter being an earlier maturing variety. It is worthy of note that the plot given a third irrigation in March, and which produced excessive growth, had up till May not a single ripe boll. Three successive heavy frosts were recorded on 28th, 29th, and 30th May, the effect of which was to finally arrest the plant processes. Most of the bolls which had not previously opened, now, with further frosts opened up, and were picked during June. The seeds and fibre in these were immature and of much less value than the normally ripened cotton.

The Variety Trial.

Of outstanding interest is the plot of Acala in Variety Trials section. This plot germinated well, making good headway in the beginning of

the season, and flowered, not sooner than other varieties, but more evenly, resulting in a much greater number of early bolls. The bolls picked were of a large size with lengthy fibre.

Persons desirous of growing trial patches of cotton would do well to confine attention to this variety until an earlier maturing one may be imported or bred.

Conclusion.

The yields of cotton from the plots were, apparently on account of the unusual seasonal conditions, very low, and only a proportion of the crop harvested comprised first quality seed cotton. The highest yield obtained was 300 lb. per acre—this from the early variety Acala

It would appear from the result of these experiments that cotton-growing on a large scale in districts comparable to Wahgunyah is not at present warranted, but that there is some possibility of its becoming, by the introduction of early-maturing varieties and judicious control of watering, a useful side-line to the Murray Valley farmer.

Meteorological Records at Wahgunyah.

For growing period of Cotton during 1922-3 and 1923-4.

1922-3.

Month.	Rain.	Evap.	Air Temperature.				Soil Temperature.				
			Dry. Ord.	Max.	Min.	Mean.	Max.	Min.	Max.	Min.	Mean.
Oct., 1st half ..	94	1.4	54.3	63.9	44.5	58.4	57.3	46.3	55.3	50.0	52.2
Oct., 2nd half ..	50	1.9	65.5	76.1	49.2		64.4	54.4	62.0	56.0	59.2
November.. ..	1	5.5	67.4	75.1	46.0	60.9	76.2	51.8	69.0	59.0	64.0
December	106	8.3	68.6	89.2	50.3	69.7	87.2	64.3	79.3	69.2	75.0
January	34	9.7	71.6	85.4	55.4	70.4	87.7	65.7	80.5	72.2	76.5
February	1	8.0	73.0	91.7	55.1	73.4	90.6	67.6	82.7	69.7	77.6
March ..	1	7.7	71.2	85.6	50.6	68.1	83.4	65.6	77.5	68.3	73.7
April	22	4.7	60.1	77.1	44.7	60.9	67.3	53.5	64.2	56.9	60.5
May ..	201	2.36	49.6	67.2	42.6	54.9	..	..	..	..	..

1923-4.

Month.	Rain.	Evap.	Air Temperature.				Soil Temperature.				
			Dry.	Max.	Min.	Mean.	1-in.		6-in.		Mean.
							Max.	Min.	Max.	Min.	
October	188	3.3	58.4	68·4	44.7	56·5	63·0	52.0	59·0	52·0	56·5
November ..	107	5.3	63.0	74·3	43.2	58·8	77·9	56.8	70·0	59·0	66·0
December ..	192	7.4	74.0	82·0	57.0	69·5	89·0	66.0	80·0	67·0	75·5
January	169	7.4	70.6	87·0	53.0	70·0	87·0	67.0	80·0	69·0	76·0
February	236	6.1	68.0	82·0	54.0	68·0	86·0	63·3	78·3	66·6	73·5
March	195	5.3	66.4	79·0	53.0	66·0	60·6	59·5	73·8	61·5	69·0
April	218	2.66	..	65·7	41.9	53·8	..	..	..	..	..
May	..	..	..	57·3	39.0	48·1	..	..	..	..	..

BEEKEEPING.

F. R. Beuhne, Government Apiculturist.

Beekeeping, though one of the minor rural industries, is in Victoria capable of great expansion as an independent industry and also as a profitable sideline to other rural pursuits. The amount of honey consumed annually per head of population is much less in Australia than in America and other countries, and could, with better methods of production, marketing, and distribution, be considerably increased. The honey flora of the State, consisting chiefly of the many different eucalypts, as well as introduced plants, such as clovers and lucerne, is equal to that of any other civilized country.

THE BEES.

Honey bees were first brought to Australia in 1822, and have since spread over nearly the whole of the mainland and some of the adjacent islands. All the wild bees found in trees, rocks, &c., are of the introduced species; the native bee is only about the size of a house fly, and of no economic value. All bees of the introduced species found in the wild state as swarms, or as nests in hollow trees, can readily be domesticated and kept in modern hives with the combs contained in frames.

The honey bee is a social insect which can exist only in comparatively large communities, a fact which must not be lost sight of when bees are kept for profit. A bee community or colony consists of three kinds of bees—the queen bee or mother of all the inmates of the hive, the worker bees, and the drones. The queen and the workers are of the female sex; the drones are the males. The queen bee is the only fully developed female of the hive, and is capable of depositing up to 3,000 eggs into the cells of the comb in 24 hours. The life of the queen bee is from two to three years; that of worker bees, however, is only from seven to eight weeks on the average during the season of greatest activity, so that a high rate of reproduction is necessary to maintain in the colony the requisite number of individuals essential to the continued existence of the bee community, and provide for the propagation of the species by swarming. The minimum number of bees that can continue and increase is somewhere about 1,000, but a strong colony may contain up to 70,000 bees.

The comb built by bees in a state of nature consists of two kinds of cells—worker cells and drone cells. The worker cells are one-fifth, and the drone cells a quarter, of an inch in diameter. The former are the cradles in which worker bees are reared, while the drones are raised in the latter, the larger cells. Both kinds of cells, however, are also used for the storage of honey and pollen. Queen cells are quite distinct, and are constructed only when required, as when bees swarm or when the queen fails or dies. They are much larger, being from 1 to 1½ inches long, and point downwards instead of horizontally, and are generally on the edge of the comb.

The Hive.

In a state of nature bees will gather sufficient stores to carry them through the winter months or tide over adverse seasons. When kept

in common boxes, they will sometimes give a fair return, and, when not robbed too late in the season, will collect enough stores after robbing to carry them through till the following spring. An adequate return from bees can, however, be obtained only, and their continued profitable existence secured, when they are kept in modern frame hives.

The hive most generally in use in Victoria is that known as the "Langstroth," of either the eight, nine, ten-frame, or even larger size. Whatever size is adopted, the walls should not be less than seven-eighths of an inch in thickness, otherwise extremes of temperature will affect the colony of bees.

Capacity of Hive.

The question of size or capacity of each section or chamber of a hive is largely a matter of individual inclination and convenience, and has no bearing on the return obtained from bees, provided that the hive selected can be expanded by tiering up, or contracted to the needs of the colony, under the varying conditions of season and food supply.

In a state of nature the combs of a bees' nest are continuous from top to bottom, and the nest is, as a rule, of greater dimensions vertically than horizontally, so that a three-story eight-frame hive conforms better to the habits of the bees than a two-story twelve-frame. Beginners and amateurs generally expect bees to work and produce a good return in a single story or a one-and-a-half story hive, which is altogether too small during the height of the season for any colony worth keeping. Such a hive is quite large enough for winter, but as soon as it becomes crowded with bees additional space should be provided by adding another story, and a third when the second one is fully occupied, otherwise there will be much swarming and a poor yield of honey. On the other hand, a hive may be too large for the colony it contains, so that the bees cannot effectively control the temperature and hive atmosphere.

The Eight-frame Standard Hive.

The body of the hive is made of $\frac{7}{8}$-in. timber, pine or redwood being preferable, and is of the following dimensions:—

Outside—Length 20 inches, width 13$\frac{7}{8}$ inches, depth 9$\frac{1}{2}$ inches.
Inside—Length 18$\frac{1}{4}$ inches, width 12$\frac{1}{8}$ inches, depth 9$\frac{1}{2}$ inches.

The hive floor or bottom is best made of redwood $\frac{7}{8}$ inch or not less than $\frac{5}{8}$ inch thick, with rests of 3 x 2-in. jarrah or redgum to resist white ants. The measurements are—

Floor board—Length 22 inches, width 13$\frac{7}{8}$ inches, thickness $\frac{7}{8}$ or $\frac{5}{8}$ inch.
Cleats (rests)—Length 13$\frac{7}{8}$ inches, width 3 inches, thickness 2 inches.
Risers (two)—Length 19$\frac{1}{8}$ inches, width $\frac{7}{8}$ inch, thickness 5-16 inch.
Riser (one)—Length 13$\frac{7}{8}$ inches, width $\frac{7}{8}$ inch, thickness 5-16 inch.

The hive cover shown in the illustration is of the same dimensions, but without risers.

The Ten-frame Hive.

This is in favour with some commercial apiarists, and used as a two-story. The extra weight of a full upper story is rather too much for the average individual, and, as pointed out above, the eight-frame can

be tiered up, and the same result obtained with greater ease in handling. The ten-frame hive is of the following measurements:—

Body—Outside length 20 inches, width 16 inches, depth 9½ inches; inside length 18¼ inches, width 14¼ inches, depth 9½ inches.
Bottomboard—Length 22 inches, width 16 inches, thickness ⅝ to ¾ inch.
Rests—Length 16 inches, width 3 inches, thickness 2 inches.
Risers (two)—Length 19⅛ inches, width ⅞ inch, thickness 5-16 inch.
Riser (one)—Length 16 inches, width ⅞ inch, thickness 5-16 inch.

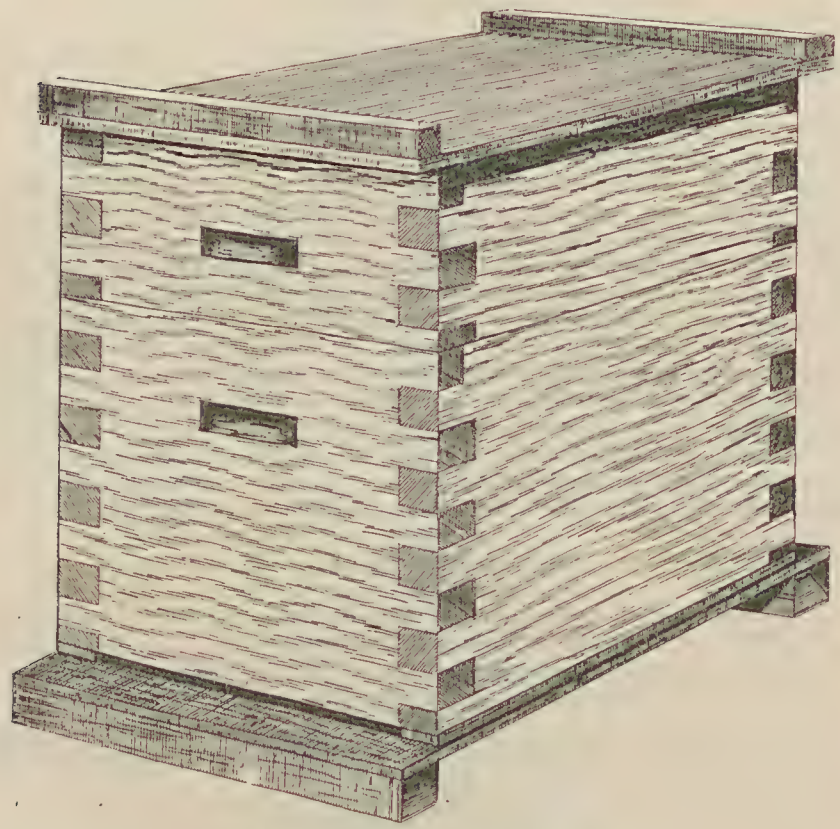


Fig. 1.—Eight-frame Standard Hive.

Temporary Home-made Hive.

A serviceable temporary hive can be made out of a good petrol case, the sides of which are not less than ½ inch thick. The case should be carefully taken to pieces to prevent splitting the boards. The ends are usually 14 inches long, and should be reduced in length to 13 inches, so that with ½-in. or 7-16-in. boards for the sides the hive body will be of the same outside measurements as the eight-frame standard hive, and interchangeable with it, but will hold nine frames, taking the same floorboard and cover as the eight-frame. Floorboard and cover can also be made out of case material, but the latter should be made weather-proof by a covering of tin or iron. A small piece of wood 7-16 inch wide

and $\frac{5}{8}$ inch deep should be cut out of the end boards of the petrol case to take the frames, the top bar of which is 19 inches long with a lug $\frac{3}{8}$ inch thick, which leaves $\frac{1}{4}$ inch for bee space between tops of the frames and the hive cover. The best instrument with which to perform this operation is a tenon saw or a rebate plane.

Frames.

Every modern hive requires frames, and of the different types obtainable from dealers the writer recommends that known as the "Victorian" frame, as having advantages not possessed by the others. It is a self-spacing frame, that is, when pushed close together the combs are the correct distance from each other. This frame was adopted as the

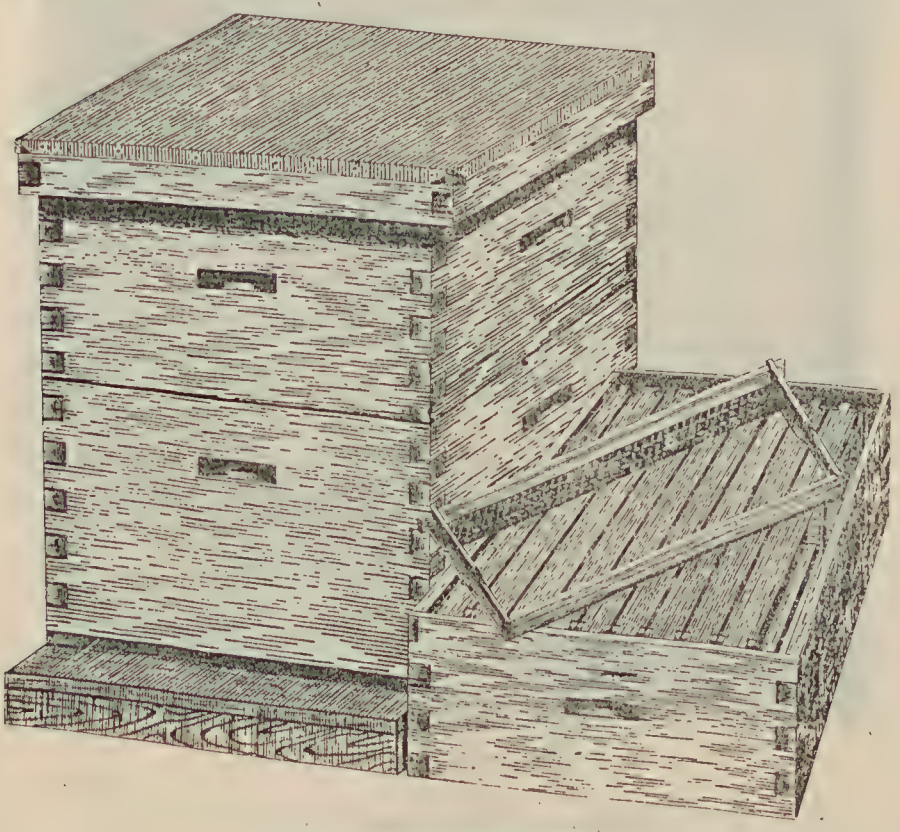


Fig. 2.—The Ten-frame Hive.

"standard" by the Victorian Apiarists Association in 1916, and has given every satisfaction to all who have used it, and is gradually replacing in established hives the other frames as they require renewing.

It is a modification of the Hoffman self-spacing frame, the useless alternate V edge of the end bars having been abandoned in favour of a square face, so that now there is only one way in the Victorian pattern of setting up the frame, instead of three different ways. End and bottom bars of the new frame have been strengthened, and the too bulky top bar of the original Hoffman reduced in thickness, so that the new type contains the same amount of timber distributed differently, giving the frame greater strength without increasing the cost.

The "Victorian" frame is an oblong square of $17\frac{1}{2}$ inches by $9\frac{1}{8}$ inches, and will fit any kind of Langstroth hive. The dimensions are—

Top bar—Length 19 inches, width $\frac{7}{8}$ inch, thickness $\frac{5}{8}$ inch; ends reduced to $\frac{3}{8}$ inch thickness for $1\frac{1}{8}$ inch.

Bottom bar—Length $17\frac{1}{2}$ inches, width $\frac{7}{8}$ inch, thickness $\frac{3}{8}$ inch.

End bars—Length $9\frac{1}{8}$ inches, width $1\frac{3}{8}$ inch for $3\frac{1}{2}$ inches from top; $1\frac{1}{8}$ inch for $5\frac{5}{8}$ inches from bottom up.

End bars are rebated $\frac{7}{8}$ x $\frac{3}{8}$ inch to take ends of top and bottom bars.

Thickness of end bars, $\frac{3}{8}$ inch.

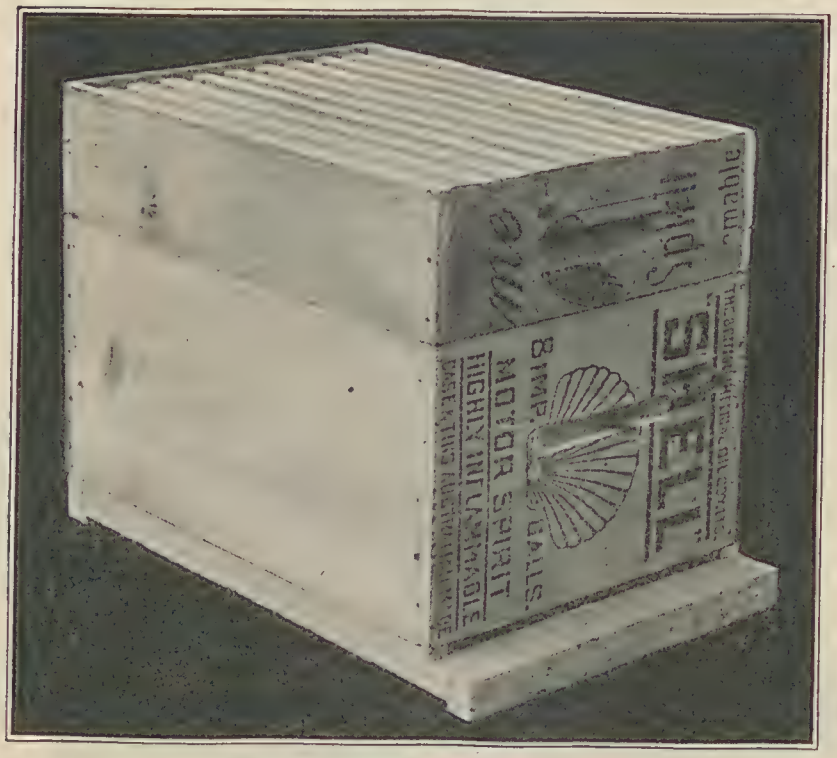


Fig. 3—Temporary Home-made Hive.

Shallow or Half-depth Supers.

In the case of beginners and amateurs, when the number of hives does not justify the expense of a honey extractor, the cutting-out method of obtaining the honey may be used. Seeing that the comb is removed every time honey is taken, and new comb has to be built by the bees, as large a yield of honey cannot be expected as when the combs are extracted and returned empty to the hive to be refilled. The building of comb requires a concentration of the bees, and therefore less space is necessary in the super or upper story, and a half-depth or shallow super, as shown on the eight-frame hive (Fig. 1), and alongside the ten-frame hive (Fig. 2), will better answer the purpose than the full-depth upper story. Even when the strength of a colony is such that a full-depth super could be used, it is better to have two shallow stories,

because shallow frames for cutting out can be used without wires, which cannot be done with the full-depth without risk of the combs breaking down in hot weather. Further, as the combs in the upper story should never all be cut at the same time, the combs containing the ripest honey can first be dealt with. After cutting them out (all but a narrow strip on the top bar to act as a guide for the building of the new comb), the frames are returned to the hive. The unfinished combs which remained will be finished while new combs are building, so that there is no total interruption in the work of the bees.

Measurements of Shallow Supers and Frames.

Body—

Outside—Length, 20 inches; width, eight-frame 13⅞ inches, ten-frame 16 inches; depth, 4¾ inches.

Inside—Length, 18¼ inches; width, eight-frame 12⅛ inches, ten-frame 14¼ inches; depth, 4¾ inches.

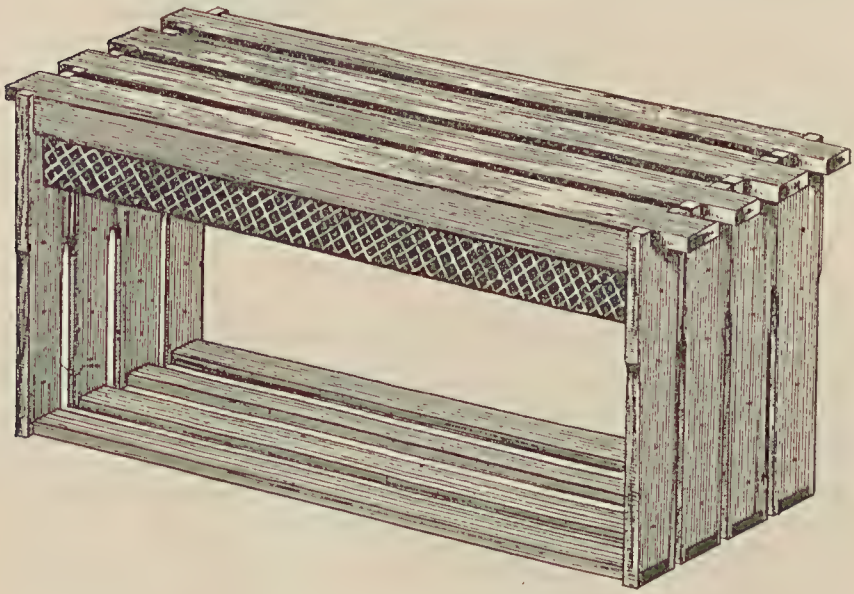


Fig. 4.—Victorian Frame.

Frames—

Top bar—Length, 18 inches; width, ⅞ inch; thickness, ⅜ inch.

Bottom bar—Length, 17½ inches; width, ⅞ inch; thickness, ¼ inch.

End bars—Length, 4½ inches; width, 1⅜ inch; thickness, ⅜ inch. Rebated ⅞ x ⅜ inch at one end and ⅞ x ¼ inch at the other to take top and bottom bars.

Hive Covers.

In the matter of hive covers there is usually more neglect shown by owners of bees than in any other feature of the hive. Yet it is upon the effectiveness of the cover that the durability of the hive itself and the prosperity and health of the bee colony largely depend. When hives, however well made, are covered with loose boards, pieces of iron, tin,

or bark, and bags, these materials absorb water or conduct it into the hive at the edges; thus they cause warping of the hive walls, and mouldy combs, and provide a convenient harbour for ants, spiders, and other insects.

A hive cover should above all things be waterproof, but it should also be so constructed that it will throw the water clear of the hive walls, and prevent the extremes of heat and frost affecting the bees from the top. After using extensively for a number of years the six different hive covers catalogued by manufacturers of beekeepers' supplies, the writer found that a flat cover, telescoping over the hive body, covered with plain galvanized iron, and insulated with layers of paper between the boards and the covering iron, proved the best in every way. This is now stocked by supply dealers, under the trade name "Beuhne Cover," and, although the most effective, its first cost is less than that of other covers, and it does not require repainting, as wooden covers do.

This cover consists of a rim of $\frac{7}{8}$-in. wood to which $\frac{3}{8}$ or $\frac{1}{2}$-in. boards are nailed, which in turn are covered by galvanized iron, turned down over, and nailed to the side of the rim. The rim should be $\frac{1}{4}$ inch longer and $\frac{1}{4}$ inch wider inside than the outside of the hive.

Telescoping Hive Cover, Eight-frame Size.

Rim, outside—Length, 22 inches; width, 16 inches; depth, $1\frac{1}{2}$ inch.

Rim, inside—Length, $20\frac{1}{4}$ inches; width, $14\frac{3}{8}$ inches; depth $1\frac{1}{2}$ inch.

Covering boards—Length, 22 inches; width, 15 inches; thickness, $\frac{3}{8}$ to $\frac{1}{2}$ inch.

The under edges of the rim are weathered to the outside to throw the drip clear of the hive.

Plain galvanized iron of 26 gauge will be found most suitable. Seventy-two inches by 36 inches, which is a trade size, would cut six pieces 24 inches x 18 inches, and thus cover six hive-roofs, allowing 1 inch to be turned down all round. The cover may be home-made out of the boards of the sides, top, and bottom of petrol or other cases. Two layers of boards are nailed together crossways to form an oblong square measuring $20\frac{1}{4}$ x $14\frac{3}{8}$ inches, to which the rim is nailed, instead of the boards to the top of the rim as in the manufacturer's cover.

The ten-frame hive cover as shown in Fig. 2 is of the same measurements as the eight, except that it is 2 inches wider, 18 inches outside, and $16\frac{3}{8}$ inches inside, instead of 16 and $14\frac{3}{8}$ inches respectively.

Cost of Hives, Frames, &c.

The price of hives, frames, and other beekeepers' requisites is subject to fluctuations, but is approximately as follows, according to kind of timber:—

(1) Eight-frame hive, one and a half story (Fig. 1), with wired frames and full sheets of comb-foundation in body, and starters in shallow frames of super, floorboard and cover, made up, ready for bees—

Unpainted	...	...	28s. to 32s.
Painted	...	...	30s. to 36s.

(2) The same wired as above, but with starters only, instead of full sheets in lower body—

Unpainted	22s. to 26s.
Painted	24s. to 28s.

(3) Ten-frame hive (Fig. 2), with full sheets of foundation—

Unpainted	40s. to 42s.
Painted	43s. to 45s.

(4) Victorian frames in flat ready to nail together, per 100, 28s. to 31s.

Half-depth frames, for shallow supers, per 100, 25s.
Comb-foundation, seven to eight sheets to the pound, 3s.
Honey extractor, two-comb, reversible, £6 15s.
Honey extractor, two-comb, non-reversible, £5 10s.
Corneil bee smoker, 3½-in.—brass 11s., tin 7s. 6d.
Bee veils, black, 3s. to 3s. 3d.; white, with black face-piece, 3s. 6d.

Complete price list of hives and bee goods is obtainable on application from W. J. and F. Barnes, Swan-street, Burnley, and V. W. Benn, Sunshine.

CLEAN MILK.

Important Factors in its Production and Despatch.

By A. W. Bethune, Dairy Supervisor.

Much has been written in the past on this subject, yet, in my opinion, gained from practical experience previous to joining the Department of Agriculture, and from a close study and observation since, there are certain requirements connected with the production and sale of clean milk which are of the utmost importance, and cannot be too often or too strongly stressed. On many dairy farms these essentials are carried out in a very cursory manner, and in some cases they are almost totally neglected. Assuming that the ordinary sanitary precautions are taken after each milking, i.e., sweeping and flushing out of bails and cooling room, removal of manure, &c., the very important requirements referred to above are as follows:—

1. Complete sterilization of all empty return cans, water cooler, and all utensils;
2. A proper system of leg-roping of cows, and washing and drying the cows' udders.

It is remarkable to find the number of dairy farmers who still follow antiquated methods of attending to this most important work of sterilization of utensils, &c. Cans arriving back from the retailer are, in some cases, not rinsed out at all, or, at the best, with cold water only. A few dairymen use warm water, and it is to be found that only a minority scald their cans with boiling water or steam and turn them upside down to cool off and dry. By not sterilizing his cans the dairy farmer is depending solely on the methods and cleanliness of the retailer he is supplying. If these are not what they should be, then when milk is again put into the cans it is bound to become contaminated. No matter how careful the retailer may be, it is practically impossible for him, on account of the structure, and, in many cases, battered condition of the cans, to destroy all the micro-organisms inside them. If these are not

checked by means of a steam jet or scalding water on the return of the cans to the farm, the organisms will rapidly multiply and contaminate the next milk they come in contact with, long ere it reaches the retail dairyman, not to mention the consumers.

It should be every dairy farmer's endeavour to install a steam-generating plant of some description on his premises, or at any rate make certain that there is always a plentiful supply of boiling water on the spot so that all cans may be scalded on return. After this operation they should be turned upside down on the rack to dry and cool off. Cloths on no account should be used on the cans after they have been scalded. Utensils which come in contact with milk should, after a preliminary rinsing in cold water and washing in hot soda water, be finished off exactly like the cans. All cloths used should be boiled at least once a day. The way utensils are washed on some dairy farms is very unsatisfactory. The "washer-up" starts off with a limited amount of "nearly boiling" water, and towards the end of the operation he is perhaps doing more harm than good with a quantity of luke-warm polluted water and a foul cloth.

A leg rope should be provided for each bail. This should obviate the dirty method so common in many sheds of each milker using one rope only, which means continual fastening and unfastening it at each end with each cow milked. They should be left attached to the posts at the rear of the bails, and only taken off to be cleaned or disinfected. These ropes should preferably be of green hide, as, when wet and soiled, there are no strands to become loose, and they do not swell and absorb moisture to the same extent as the fibrous ropes. On most farms green hide ropes are easily procurable.

All cows on entering the bails should be leg-roped immediately, and, if there be more than one milker, one person should be detailed to wash and dry the cows' udders. In a season like the present it is almost impossible to eliminate the mud nuisance, and here is where the greatest care is necessary in order to keep the milk pure. Milk cannot be kept free from dirt if the milker sits down with his milking bucket in one hand and in the other a utensil containing a quantity of polluted water, together with a dirty cloth. When the udders are soiled there should always be provided an abundance of warm water with which common soap or a little washing soda may be used. The washing vessel should be frequently replenished. A cloth is necessary for cleansing the udders, and some sort of cheap towelling is necessary for drying them. A 72-lb. sugar bag opened up and cut to the desired size and hemmed around the borders will be found suitable for these purposes. These cloths require scalding and ringing out after each time they are used. It is very necessary to dry the udders after washing. If the hairs on the udders and lower flanks are kept clipped short, the udders are much more easily cleaned. It is very important to clean the udders at all seasons of the year. When there is no mud, and they are not soiled, they should be wiped over with a damp cloth previously wrung out in water containing a few drops of formalin. If the hands are kept clean and the milk carefully cooled, and not stored on the farm longer than is really necessary, and the suggestions made above carefully carried out, there is no reason whatever why the average dairy farmer should not produce and despatch to the metropolitan supply first grade milk.

COST OF REARING AND FATTENING PIGS.

By A. J. Gill, Dairy Supervisor.

The development of the pig industry promises to become of great importance in rural districts, and there is reason to believe that in the near future it will be one of the greatest sources of wealth of the State, for the conditions generally, particularly our climate, are extremely favorable.

The numerous farms under irrigation provide lucerne for grazing purposes which reduces the cost of keeping sows and stores to a minimum. To the dairy farmer, the pig is indispensable if dairying is to be as remunerative as it should be. It is in a great many cases the most profitable animal on the farm, and in periods of depression the means of turning otherwise unsaleable root or grain crops into money showing substantial profits, when a serious loss would have been inevitable. To the tenant-farmer the pig is a valuable asset, and with careful handling will pay the rent, leaving the return from butterfat and other stock money as clear profit.

Unfortunately, in a number of cases people seem to think that pigs and dirt should go together, and frequently one finds pigs in yards leg deep in mud, a little damp, dirty straw on a few slabs in a low draughty sty being provided for bedding. Though under these unfavorable conditions the rearing of pigs may be profitable, if carried on under more favorable conditions the results would be much better, less food would be required, there would be fewer losses from disease, and the handling would be much more pleasant.

Well-drained sites should be always chosen for the styes. Low ground towards which drainage will gravitate must be avoided. The sides of gullies are usually draughty and cold, and therefore not suitable. Shady trees in or near the run will add greatly to the comfort of the pig during the summer. The sty should be sufficiently high for a man to stand up in. The old-fashioned low sty has nothing to recommend it. The lower the roof the hotter the sty and the less fresh air available, and fresh air is a vital necessity to the pig. The walls of the sty should be snug and draught-proof, and in cold weather the pig should be supplied with a fair supply of dry bedding. In order to get the best results pigs must be kept free of vermin; this object can be best attained by the use of oil or germicidal washes.

In breeding pigs it is very necessary to have a first class boar and good sows. If possible sows whose mothers have proved themselves prolific breeders should be purchased; lengthy, deep animals of good type are the best desirable. A beginner should obtain the assistance of an experienced breeder with a well-trained eye to help him in selecting his foundation stock. A sow which breeds pigs of weak constitution should at once be put in the fattening pen. I have seen keen farmers, after their pigs had been in the fattening pens for 2 or 3 weeks, cull out any animal that was not making headway as quickly as they wished and send it to the market as a store. This practice seems to indicate that it is a better policy for a farmer to breed his own pigs than to depend on the market. In breeding them on the farm the risk of bringing contagious diseases there is eliminated.

This year, in order to determine the actual profit that could be made under the ordinary conditions obtaining on the usual farm, an experiment was carried out at Mr. O'Reilly's farm at Leitchville. An account of the expenses was kept from the date on which the sows were

served. A month after being farrowed the young pigs were weighed. Various sizes were selected in order to arrive at a correct estimate: eight were chosen from four litters—two from each. Of the four sows two were Berkshires, two Berkshire Tamworth crossbreds, and the sire was a pure Tamworth. The young pigs were weighed monthly until ready for sale. The food used was crushed barley and separated milk; the barley was valued at 3s. 4d. per bushel, and the milk at 1½d. per gallon. A couple of the sows farrowed on the 4th of March, the others on the following day. The average number of each litter was eight. During the sixteen weeks prior to farrowing the sows were allowed, in addition to pasture, 5 lb. of crushed barley per day, thus 560 lb. of grain was fed to each sow at a cost of £1 17s. 4d., or 4s. 8d. per week. After farrowing the sows were given 6 gallons of milk and 1½ lb. of grain daily for 49 days. The young pigs were then weaned, and for 21 days were fed ½ lb. of crushed grain and two-thirds of a gallon of milk daily. For the next 28 days the allowance was 1 lb. of grain and 1 gallon of separated milk per day; then for 38 days they received 3 lb. of grain and 1 gallon of milk daily, and for the last 34 days were fed 6 lb. of grain and 1 gallon of milk as the daily allowance. The following table gives the dates of weighing the young pigs, their ages at time of weighing, their average weight, and the cost to date of maintaining them:—

Date of Weighing.	Age.	Live Average Weight.	Cost of Maintenance.
			£ s. d.
	Feed to sow for sixteen weeks prior to farrowing		0 4 8
April 4 ..	31 days	19·25 lbs.	0 7 10
May 9 ..	66 „	41·66 „	0 12 0
June 11 ..	98 „	66·86 „	0 17 8
July 18 ..	136 „	111·13 „	1 9 8
August 20 ..	170 „	153·47 „	2 7 10

Thus at the end of 170 days the average weight of the young pigs was 153.47 lb. Assuming the dressed weight of each to be 125.113 lb., and the value of pork 9d. per lb., the value of each pig was				£4 13 10
The value of grain (70 lb.) fed to each sow before farrowing was	£0	4	8	
The value of grain (365-6 lb.) fed to each young pig was	1	4	4½	
The quantity of milk fed to each was 150.6 gallons, and its value was	0	18	9½	
				£2 7 10
Leaving a profit of				£2 6 0

The weight of the heaviest pig 31 days after birth was 23 lb., and of the lightest 15½ lb. At the end of 170 days the heaviest one turned the scale at 180.8 lb., and the lightest at 119 lb.

The quantities of food used in the test were supplied by Mr. O'Reilly, and were checked monthly by the departmental officer, who also weighed the pigs.

"VERDELLI" OR SUMMER LEMONS.

By S. A. Cock, Government Citriculturist and F. de Castella, Government Viticulturist.

The Algerian Government Bulletin of August last reproduces extracts from an article which appeared in the *Bolletino Della Camera Agrumaria* of Messina (Sicily), describing the methods followed in that country to artificially force the production of summer lemons. The following translation will no doubt interest our citrus growers:—

The Italian lemon campaign comprises, in the main, two phases of which one, that of the ordinary or main crop lemons, lasts from Christmas to spring, whilst the other known as "Verdelli" corresponds with the summer.

The Verdelli, which owe their name to their characteristic green colour, are obtained in summer by forcing the trees to bear at an abnormal time of year and at a season when the demand is most active; they have the advantage of supplying an important export trade, especially overseas. The industrial production of the "Verdello" is the outcome of the decline in lemon prices which occurred in Sicily during an intense citrus crisis. Having no means of maintaining lemon prices at a high level, producers had the idea of augmenting the yield of the summer season, that is to say, when the fruit is more sought after and better paid for.

Verdelli production may be natural or artificial. The lemon flowers from spring to summer, the fruit ripening, successively from winter to summer, and passing under designations varying according to the time of ripening and harvesting.

The fruit which ripens in summer is the natural Verdello; it is usually gathered before maturity, when the tree is already loaded with flowers and immature fruit.

If the tree is forced by the hand of man to blossom, at the end of summer, the fruit of the following summer is termed artificial Verdello. It is the yield of this class of fruit which presents the greatest commercial importance, since it permits the marketing of lemons during the season of greatest demand.

The method of producing Verdelli artificially is very simple: The tree is made to undergo a forced drought from June to mid-August (December to mid-February in Australia). This delays bud development and lowers to some extent the vitality of the plant. Then by again applying irrigation at this period, which may vary somewhat according to the type of soil, life is once again infused into the lemon tree, provoking late blossoming in September (March with us) which will in due course develop into the Verdelli of the following summer.

This operation, which constitutes a veritable torture for the tree, is extremely delicate and needs all the attention of the citriculturist, who must be well acquainted with his trees and their power of resistance; as a rule, the treatment is practised on one-third or one-fourth of the orchard only, so as to allow the trees to rest for three or four years.

Previous to the operation, the zone of the orchard intended for the production of Verdelli is treated from October to February with well

decomposed farm-yard manure, supplemented by stimulating artificial fertilizers before irrigation.

The trees destined for Verdelli production must be properly cared for and very well nourished. The success of the crop depends not only on the duration and timing of the forced drought and on the nature of the soil, but also on the age of the trees, and the climatic conditions of the preceding seasons.

Lemon trees suited for Verdelli are those of medium size with short growths, normal leaves, and fruit which are numerous but not large. As many as 1,000 Verdelli can be obtained from a properly-treated tree.

It is well to remark, however, that if, under normal conditions the production of Verdelli is more profitable than that of ordinary lemons, it is at the cost of prematurely ageing the orchard yielding them, which does not last longer than about 40 years.

Be this as it may, this industry merits investigation, so as to obtain from it the maximum yield compatible with the preservation of the tree.

From a commercial stand-point the Verdello is the essential factor in the Italian citrus trade with the United States. Though less rich in juice than the ordinary lemon, owing to its firmness, fine appearance, keeping qualities, and great evenness, and especially because available at a season more favorable for its consumption, it is, of all Italian lemons, that upon which growers can best rely. Notwithstanding the intrinsic superiority of this fruit the *Bolletino Della Camera Agrumaria* recommends, in connexion with the packing of Verdelli, the application of every care needed for the improvement of the citrus trade generally, such as elimination of inferior fruit, accurate and reliable grading according to size, choice of good material for the cases, with adoption of the standard type of packing used in California, and, lastly, regularity in shipments, so as to avoid accummulation of stocks in quantities in excess of consumption; pooling of individual consignments, with elimination of speculative buying and publicity propaganda.

STATE LIBRARY MELBOURNE

WHITE ANTS IN THE ORCHARD.

In localities where white ants are prevalent it is desirable to cultivate a crop before planting fruit trees. In any case it is a good plan to do that first, but if it is not possible, the land should be ploughed early so that the soil is exposed to weather influences for some time before planting is carried out.

The land should be thoroughly cleared, of course, all roots being run to a proper depth, and all pieces of timber removed or burnt. In localities where white ants are troublesome stakes should not be used to support trees unless such stakes have first been treated with an effective white ant exterminating dressing; nor should use be made of mulches such as bush scrapings, grass, &c. Thorough cultivation helps to keep white ants in check.—*Agricultural Gazette* of New South Wales, June, 1924.

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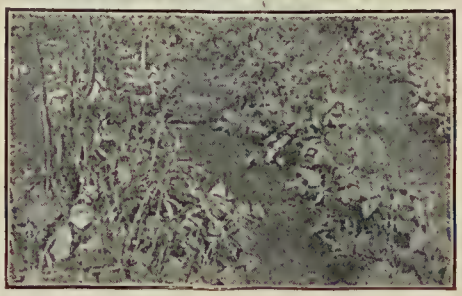

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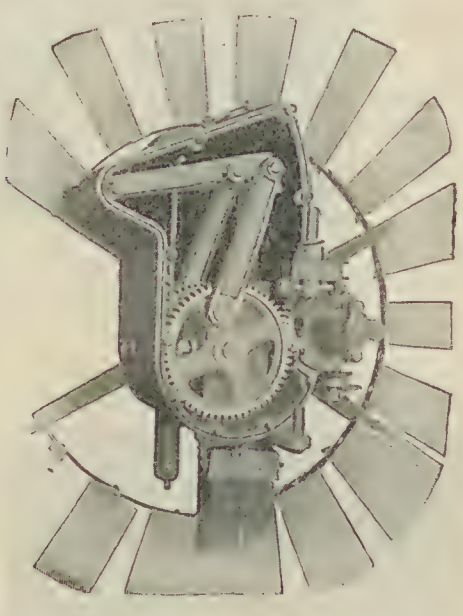

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DEPARTMENT OF AGRICULTURE, VICTORIA

Red Poll Dairy Herd

The Department has now completed the orders for calves that were booked ahead of calving when the advertisement was withdrawn; consequently the booking of orders for bull calves from the forthcoming calvings has now been resumed.

BULL CALVES are sold for delivery at a month old at prices based approximately on the actual milk and butter fat record of the dam at the rate of 1s. per lb. of butter ***fat*** yielded. Thus a calf from a cow with a 400 lbs. butter fat record is sold for 20 guineas, one from a 300 lb. butter fat cow for 15 guineas, and so on. Bull Calves *ex* heifers on their first calf are sold for a set price of 10 guineas.

(For Record of Yields of dams see Red Poll Herd Book.)

The Bulls in Use include—

VICE REGAL (95 A.A.)

Sire: Nicotine (69 A.A.). Dam: Velveteen (Imp.) 22875 (2 A.A.).

VICTORIA VOLCANO (322 A.)

Sire: Nicotine (69 A.A.) by Acton Dewstone (imp.) 9524 (4 A.A.).

Dam: Tonga (253 A.) by Honingham Archbishop (imp.) 9702 (48 A.A.).

Tonga's butter fat yields for 6 successive lactation periods are as follow:—1916, 341 lbs.; 1917, 398 lbs.; 1918, 419 lbs.; 1919, 479 lbs.; 1920, 428 lbs.; 1921, 562 lbs.

BELLIGERENT (Imported) 11096 (8 A.A.)

Dam's Record (1st milking) 7144 lbs. milk.

Dam's Dam's	,,	14533	lbs. milk	...	4	years average	12871	lbs. milk.
Sire's Dam's	,,	10370	,,	...	7	,, ,,	9354	,,
Sire's D. Dam's	,,	9510	,,	...	12	,, ,,	8033	,,
G. Sire's D. Dam's	,,	10215	,,	...	7	,, ,,	9386	,,
G.G. Sire's D. Dam's	,,	12565	,,	...	10	,, ,,	8853	,,
G.G.G. Sire's D. Dam's	,,	10088	,,	...	2	,, ,,	9754	,,

Inspection of the Herd is Invited.

Visitors will be met at the Station on notifying the Manager, State Research Farm, Werribee.

Application for purchase to

Dr. S. S. CAMERON, DIRECTOR OF AGRICULTURE, MELBOURNE.

DEPARTMENT OF AGRICULTURE, VICTORIA

FRIESIANS FOR SALE

(1) Bull Calf *ex* Dominion Hyacinth (374)

Dropped 29th August, 1923

Sire: **Victoria Songboy (359)** by Dominion Domino Dutch Boy (73 F.H.B.A.), *ex* Dominion Madrigal (371 F.H.B.A.).

Sire of Dam: **Oak de Kol 2nd Homestead Fobes** (imp. to N.Z. from America) (341 N.Z.F.H.B.).

Dam's Record for 273 days under Government Herd Test—
11,512 lb. Milk, 4·08 Test, 479 lb. Butter Fat.

For Full Lactation Period—
13,898 lb. Milk, 4·24 Test, 589 lb. Butter Fat.

(2) Bull Calf *ex* Victoria Oakdale Lassie (996)

Dropped 24th September, 1923

Sire: **Victoria Jo Patch (345)** by Longbeach Big Patch (515 N.Z.F.H.B.), *ex* Dominion Madrigal (371).

Sire of Dam: **Dominion Oakdale (342)** by Oak de Kol 2nd Homestead Fobes.

Vict. Oakdale Lassie is now undergoing her 1st test.

Her Dam, Dominion Proud Lassie's Record for 273 days under Government Herd Test—
11,336 lb. Milk, 3·42 Test, 387 lb. Butter Fat.

For Full Lactation Period—
12,216 lb. Milk, 3·51 Test, 428 lb. Butter Fat.

(3) Bull Calf *ex* Dominion Woodnymph (988)

Dropped November, 1923

Sire: **Victoria Jo Patch (345)** by Longbeach Big Patch (515 N.Z.F.H.B.), *ex* Dominion Madrigal (371).

Sire of Dam: **Woodcrest Jo** (imp. to N.Z. from America) (334 N.Z.F.H.B.).

Dam's Record for 273 days under Government Herd Test—
10,610 lb. Milk, 3·17 Test, 336 lb. Butter Fat.

For Full Lactation Period—
13,240 lb. Milk, 3·31 Test, 439 lb. Butter Fat.

The record of the dam—DOMINION MADRIGAL—of the sires "Victoria Songboy" and "Victoria Jo Patch" for 273 days under Government Herd Test is 11,373 lb. Milk, 3·93 Test, 448 lb. Butter Fat; and for Full Lactation Period 13,485 lb. Milk, 4·17 Test, 563 lb. Butter Fat. "DOMINION MADRIGAL" is a full sister to "DOMINION QUEEN MERCEDES," third cow of all breeds under Government Herd Test 1923, and Winner "Weekly Times" Butter Competition, Melbourne Royal Show 1923, and Champion Melbourne Royal Show 1923.

(4) Cow "VICTORIA DUTCHMAID" - 5 years old
(Due to calve 10th June, 1925).
Sire: Dominion Domino Dutch Boy (73). *Dam:* Dominion Milkmaid (370).

(5) Cow "VICTORIA BELLONA" - - 5 years old
(Due to calve 3rd February, 1925).
Sire: Dominion Domino Dutch Boy (73). *Dam:* Dominion Belle Corona (369).

(6) Cow "VICTORIA CORIANDER" - - 5 years old
(Due to calve 15th April, 1925).
Sire: Dominion Domino Dutch Boy (73). *Dam:* Dominion Coringa (380).

Inspection of above Bull Calves and Heifers at the State Research Farm, Werribee, is invited.

Application for Purchase to—

DR. S. S. CAMERON, Director of Agriculture, MELBOURNE

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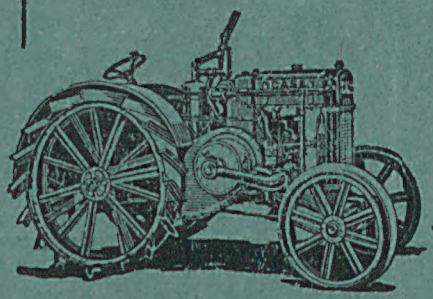

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